THE RAW MATERIALS OF THE WORLD

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THE RAW MATERIALS OF THE WORLD

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With a Foreword by
Dr. G. L. WOOD

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TO THE MEMORY OF

MY FATHER

WHO DIED IN ENSLAVED EUROPE

DECEMBER, 1941

FOREWORD

In recent years we have become aware of a more lively interest in that part of our stock of knowledge which we call geography. Geography is something of a portmanteau subject into which are packed the conclusions reached in many more exact sciences—geology, chemistry, physics, botany, zoology, as well as in many less exact studies such as meteorology, anthropology, and economics. The reason for the growing interest in geography is the need for an "all-over" school course which will give the ordinary man and woman sufficient facts to enable them to understand their environment and their society, on the one hand, and which will afford a basic approach to the problems of public administration, aviation, agriculture, trade and commerce, and international relations, on the other.

Partly, of course, this revival of interest in geography is a result of war, fast moving and global, which has splashed maps all over our daily papers and office walls, and, incidentally, convinced most of us that our knowledge of our world is rather elementary. But the war does not explain it entirely. Reconstruction is in the air, international planning has become a daily exercise for the thoughtful. We can no longer afford to be

ignorant about our neighbours. The making of world plans demands a knowledge of other countries, their peoples and their politics, their standards of living; and so, of making many books upon every aspect of a round world which continues to shrink irresistibly before our eyes, there is no end. In the very broadest way geography has re-asserted its place in the educational equipment of the good citizen, and this is causing some concern to conservatives, especially in secondary schools, who thought that geographical knowledge might safely come to an end with a pass at the intermediate examination.

Dr. Gentilli does not accept that view. He sees in the movements for regional development, for the study and classification of natural resources, and for the decentralization of industries a need for better information. He senses a new importance for geography in attempts to solve problems such as water conservation, closer settlement and migration policies, soil exhaustion, and marketing. He realizes that the answers to these questions depend upon a more accurate knowledge of the natural conditions which control human activities, i.e., geology, topography, climate and vegetation.

So there is every reason for a new book, for many new books, which will focus attention upon geography, particularly in paradoxical countries like Australia—politically "new and vigorous" but geologically so "old" and depleted. I commend

Dr. Gentilli's effort to explain these conditions in causal terms, and recommend his work to the attention of all who are interested in the developments of the future.

G. L. WOOD.

University of Melbourne.

INTRODUCTION.

When a scientific instrument or a concentrated food is sold, it is expected that the purchaser be supplied with some "directions for use" lest he may misuse the valuable instrument or the highly nutritious food.

This book aims at giving the man in the street a key to World resources at a time when so much talking goes on about planning on a World-wide scale. In this book are concentrated the essentials of location and production of all the major foodstuffs and raw materials which mankind uses to-day. This is why some "directions for use" are required.

The first aim of the present work is to provide an answer to the pertinent questions which so many people now ask whenever any branch of the World's production is mentioned: "How is it done?" "Where is it found?" "How much of it?"

The text provides the strictly essential answers to the first question. Technical notes are obviously outside the realm of Geography, and this book provides the reader with the clue from which to seek further information in specialized works.

The maps provide detailed answers to the second question. People who wish to acquaint themselves with the actual problems arising from World planning have a compact but comprehensive atlas of production at their disposal in the pages that follow. It is however necessary that they supplement the information thus gathered by using a good atlas where they can find what

may be termed the "home address" of each commodity—the nearest town, whether there is a railway or a harbour, what population density obtains in the vicinity, etc.

The diagrams answer the third question. They are devised in such a way, that they provide the hasty reader with the answer at a glance; they can be easily understood by anybody; they afford an exact and easy comparison between the production of the whole World and that of any single country, for each important commodity. On the other hand, the scientifically minded inquirer can easily find from the diagrams the exact quantity of each commodity produced by each country, simply by counting the small cubes in the relevant diagram. Since there are 10 cubes to each pile, the count is at least as easy as reading figures, and visually much more effective.

The most important sources used in the compilation of the diagrams and maps were the publications of the League of Nations and the International Labour Office, of the Imperial Economic Committee, of the Statistical Offices of many countries, Buck's "Land Utilization in China," and scientific papers scattered among various reviews, journals and magazines. The original map used as a background is on Aitoff's equal-area projection, recentred to suit Australian conditions, and shortened by 70 degrees as shown by the double line which cuts the Pacific Ocean. The statistics taken as a base for the diagrams show the greatest output for each commodity within the last ten years for which information was available; this has been done because it is hoped that artificially created scarcity will be banished, and

maximum output will be the rule in the post-war World.

So far, so good. But with a knowledge of production alone, one cannot go very far. Production, especially when agricultural or pastoral, is closely dependent on climate, and this is why climate may be termed the great elemental resource which man has to learn to understand and to utilize. Climate has pride of place in the pages that follow, and production comes after, and not, as might have seemed more attractive, before it.

Much is due to Trewartha's "Introduction to Weather and Climate" as far as places outside Australia are concerned; some additional climatic records have been obtained through Kendrew's "The Climates of the Continents." Australian records have been obtained from "Meteorological Data for Certain Australian Localities," a joint publication by the C.S. & I.R. and the Commonwealth Bureau of Meteorology.

Thanks are also expressed to all those who gave some of their valuable time to the reading of the manuscript and offering valuable suggestions: Professor F. R. E. Mauldon and Dr. Merab Tauman of the University of Western Australia and Mr. W. McLean read the first draft; Professor E. deC. Clarke of the same University and Mr. K. C. C. Tiller of Perth Technical College read the second draft; and the final script was read by Messrs. N. Sampson, Headmaster of Perth Modern School, E. Huck, J. A. McCall, and G. E. Browne. Professor E. deC. Clarke's encouragement is gratefully acknowledged.

—J.G.

CONTENTS

THE DEVELOPMENT

PRONUNCIATION OF FOREIGN NAMES.

The pronunciation of foreign names is shown in italics generally following the system adopted by the Royal Geographical Society; the system may be thus summarized: English consonants and German vowels.

a = c*a*st	*h* = *h*ot
e = t*e*st	*k* = *k*in
i = m*i*st	*kh* = loc*h*
o = c*o*st	*r* = ba*rr*en
u = f*u*ll	*s* = lo*ss*
oe = f*u*r	*th* = *th*ick
ue = French *u*	*y* = *y*ield
ch = *ch*op	*z* = ro*s*e
dh = *th*is	*zh* = plea*sure*
g = *g*ild	

Each vowel or consonant has one sound only, the one shown above. The sounds of *b*, *d*, *f*, *j*, *l*, *m*, *n*, *p*, *t*, *v*, *w* are the same as in English; *c* is replaced by *k* or *s* (*konsert*, concert); soft *g* by *j* (fringe = *frinj*); *qu* by *kw* (quart = *kwort*); mute letters are not written (treasure = *trezh'*).

• • •

According to usage, the words Sun and Earth are written with capitals when they refer to the respective astronomical bodies. By analogy, World means the whole of the Earth's surface.

THE ENVIRONMENT

I. WEATHER AND CLIMATE.

It may sound rather unusual to speak of climate as a resource, and yet it is climate as a basic World resource that will be studied here.[1] And climate's capricious counterpart, the weather, will also find its place in the pages that follow.

If a man were asked to describe yesterday's weather, he could do so by saying whether it rained, and if so, how much it rained; whether there was much moisture in the air; whether there was any wind, and if so, where it was blowing from. A more exact record of the weather would require some instruments, such as a rain gauge, a barometer, a thermometer, and so on.

A castaway landing on an unknown island would at once know the approximate weather conditions. And yet he would be unable to describe the climate of the island without living there for several years. First of all, should he land there in summer, he would have to wait until the next summer to see which season brings most rain, which season has the most regular winds, how hot it is in midsummer and how cold in midwinter. Only after a whole year would he come to know all this. And many more years would be required in order to know the average conditions of temperature, pressure and wind,

1 It is essential that the reader be thoroughly acquainted with the physiographical elements of climate as explained in a good text book, such as "Physical and Practical Geography," by Bentivoglio and Friederich

moisture and rain, all of which are needed to know the climate of the island.

Another example may help to understand the difference between weather and climate. In a botanical garden hot-house, the climate of a tropical country can be easily imitated, but it would be almost impossible to imitate the weather of such a country.

These examples show that the weather is the *actual* condition of the atmosphere during a short time, while the climate is the *average* condition of the atmosphere during a long time. The study of the weather and weather forecast is called Meteorology; the study of the climate, its causes, and its influence upon living beings and upon things is called Climatology.

The man who knows the climate of his place is at an advantage as against his neighbour who does not know anything about it: he is able to know when the rainy season is likely to start, how cold it is likely to be, what crops he may grow, and other matters of vital importance.

Climate has to be sufficiently well known before studying how man has developed the various branches of production in the World. It is impossible to understand any type of climate without knowing the most important factors which influence climate, such as latitude, moisture, temperature, altitude, position of land and sea masses, pressure and winds, ocean currents, mountain barriers, plant cover.

Various climates exist on the Earth, and just as one may distinguish physiographical Regions, or political Regions, one may distinguish climatic Regions. A climatic Region is a part of the

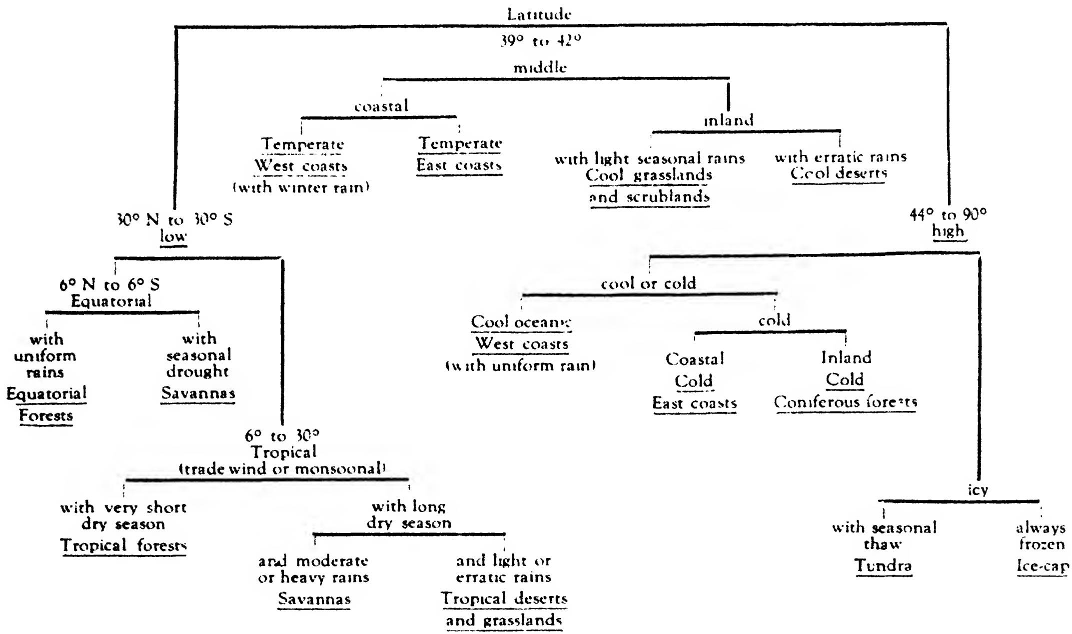
World throughout which the same climate prevails.[2]

To realise properly the relative importance of World climates one must study them on equal-area maps, in which every Region has proportionately the size it actually has on the Earth's surface.

Although a climatic Region has one prevailing climate, small areas within the same Region may have other climates, which in this case are called microclimates. The study of microclimates is one of the most fascinating parts of Climatology. The more varied the build of a country, the more numerous the microclimates, until one finds that every valley, gully or gorge, every inlet, every highland has its own peculiar local climate.

2 The most complete schemes for the classification of climates have been devised by Koeppen in Germany and by Thornthwaite in the United States. Koeppen's symbols, which are as a rule the initials of German words, are not internationally significant. This shortcoming could be obviated either by adopting initials of Greek or Latin words, or by using adjectives which can be translated. The latter method is followed here, with some simplifications.

A KEY TO WORLD REGIONS.



II. WORLD CLIMATIC REGIONS.

Since the first factor affecting climate is latitude, it may be desirable to group World climatic Regions by latitude first, in order to proceed to a more detailed study later on.

The World latitudinal zones may roughly be classed as *low*, *middle*, and *high*. The low-latitude belt extends from about 30° N. to 30° S., and therefore includes the equator and both tropics. The two middle-latitude belts extend farther polewards from about 30° to about 42°; being relatively far from the equator, they receive the Sun's rays at a slant and get on the average less heat than the low latitudes. The high-latitude belts extend from the poleward margin of the middle latitudes to the poles, namely, from about 42° to 90°; since they are still farther away from the equator the angle at which they are struck by the Sun's rays is still smalier, and they get less heat than the middle-latitude belts.

Another climatic factor of great importance to plant and animals is the relative amount of moisture. This may vary according to the seasons, and during dry seasons unless water is found in rivers, pools or wells, animals and men must migrate to wetter places, while plants which are not endowed with drought-resisting devices rapidly dry off.

It is sometimes difficult to decide whether a climate is "wet" or "dry", since the effect of rainfall varies according to the way and time it falls and to temperature. It follows that the total

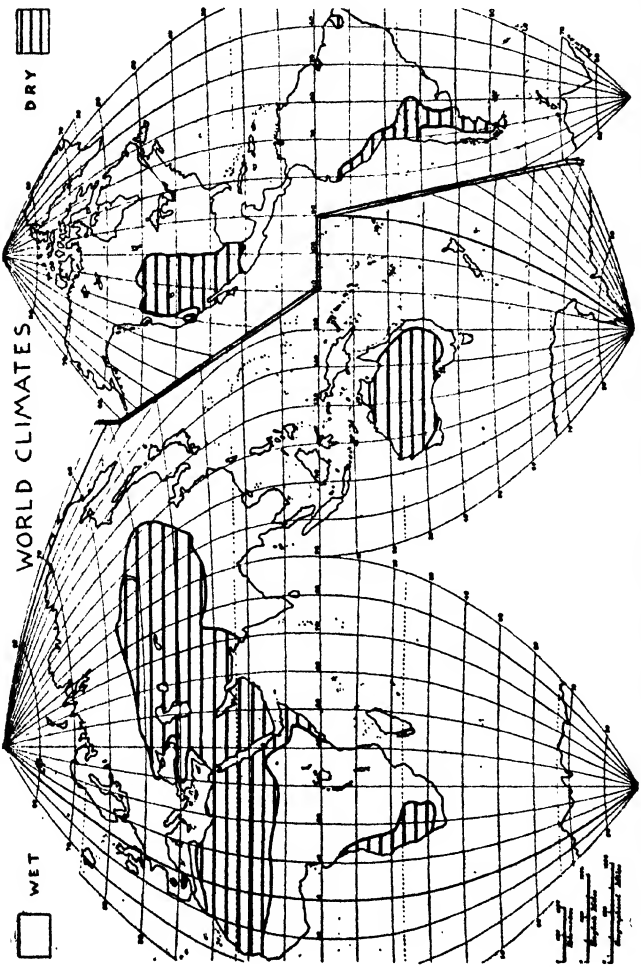
quantity of rain that falls is not a very valuable indication in itself, and it is very important to know when this rain falls. According to Koeppen, a Region receives winter rain when the wettest winter month gets at least three times as much rain as the driest summer month. A Region receives summer rain when the wettest summer month gets at least ten times as much rain as the driest winter month. A Region gets uniform (or erratic) rain when conditions are intermediate between those required for winter rain and those required for summer rain.[1]

If temperatures were always constant, the higher the rainfall, the wetter the climate. Actually temperatures vary, and an increase in the rainfall may be neutralised by an increase in the temperature, which brings a greater evaporation. It follows that rainfall and temperature must both be known in order to determine whether a climatic Region is "wet" or "dry." Moreover, since higher temperatures prevail in summer than in winter, summer rains are subject to a much greater loss through evaporation than winter rains.

The boundary between "wet" and "dry" climates may be approximately set along a line which is determined by rainfall (and any other form of precipitation) and temperature. These are the formulae, where r means total yearly rainfall (and all precipitation) in inches, and t means yearly average temperature in degrees Fahrenheit:

(a) with winter rain, $r = 0.44\ t - 14$

1. Koeppen's symbols: winter rain = *s*; summer rain = *w*; uniform or erratic rain = *f*.



Map 1.—THE WET AND THE DRY AREAS OF THE WORLD. This is a fundamental climatic classification: it affects vegetation, as it results in forests and savannas on the one hand, deserts and grasslands on the other.

(b) with uniform rain, $r = 0.44\ t - 12$

(c) with summer rain, $r = 0.44\ t - 8.5$.

If r is greater than the rest, the climate is wet; if it is smaller, then the climate is dry[2] (map 1).

If temperature alone is considered, other classifications may be arrived at. There is a certain temperature below which many tropical plants cannot subsist. This temperature, assumed by Koeppen to be 64.4°, is a useful climatic index. Regions where no month averages less than 64.4° may be termed hot[3], and are shown on map 2.

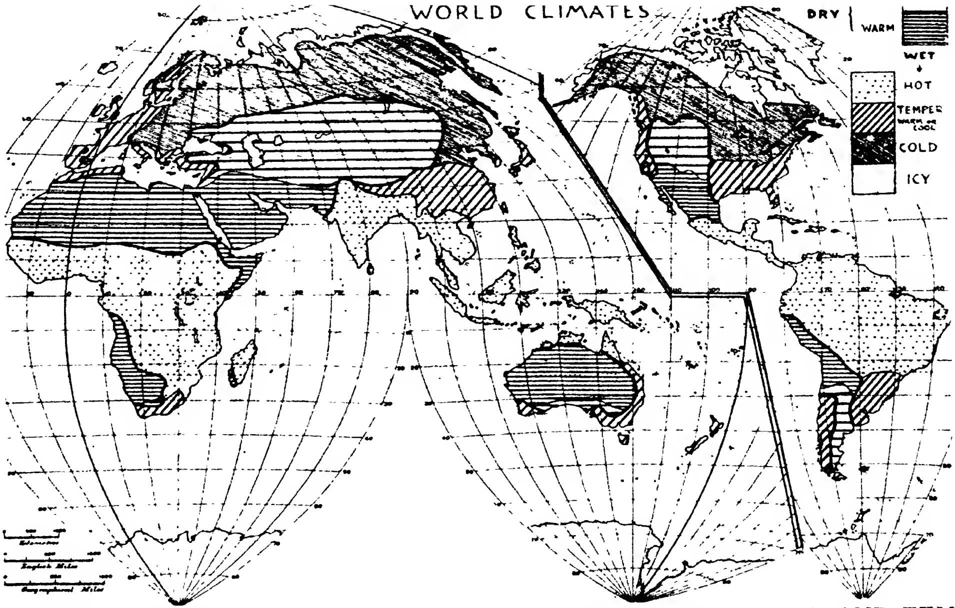
Regions where at least one month averages less than 64.4°, but no month averages less than 26.6° enjoy the sort of intermediate climate that goes under the rather vague name of temperate; there is room for further subdivisions of this climate, and for instance areas where the yearly average is less than 64.4° may be termed cool, while those areas where the yearly average is more than 64.4° may be termed warm.[4]

Those Regions where the coldest month averages less than 26.6°, but the warmest month averages over 50°, are termed cold[5]; plant life has to cease or to become dormant during a certain period, and animals must choose between winter lethargy and migration to warmer places (map 2).

Finally, Regions where there is no month over 50° are termed icy[6]; only specially adapted forms of plant and animal life may subsist under these conditions (map 2).

Altitude is a climatic factor which has a very

2. Symbol for dry climate = *B*.
3. Symbol for hot climate = *A*.
4. Symbols, temperate climate = *C*, cool = *k*, warm = *h*.
5. Symbol *D*
6. Symbol *E*.



Map 2.—THE CLIMATIC ZONES CLASSIFIED ACCORDING TO RAINFALL AND TEMPERATURE. Hot = no month below 64.4°. Temperate = one or more months below 64.4° but no month below 26.6°. Cool = yearly average below 64.4°. Warm = yearly average above 64.4°. Cold = one or more months above 50°, one or more months below 26.6°. Icy = no month above 50°.

great importance in certain areas; for instance the Andes make the climate of Ecuador different from what it would be at sea level, and vegetation changes accordingly. Other striking examples are afforded by the Alps, the Rocky Mountains, the highlands of Central Asia. Highland climates are treated in detail in Chapter VI.

It is now time to consider the great climatic Regions of the World and to study them according to their latitude, rainfall and temperature, besides those other factors such as ocean currents or regular winds which may modify climate to a very great extent.

The low-latitude belt between about 30° N. and 30° S. may be subdivided into one equatorial belt and two tropical belts; this subdivision mainly corresponds to the different amount of heat received from the Sun.

The equatorial belt may be assumed to extend from 6° N. to 6° S. and is therefore very narrow. Lands within this belt are hot and most of them receive abundant rains.

The two tropical belts extend from 6° to about 30° and include lands with widely different climates. First of all, one may distinguish those lands which are in the main under trade-wind influence from those lands which are mainly under monsoon influence. In both groups of lands, the amount of rainfall received may vary from one place to another. There are Regions which receive torrential rains. There are other Regions which receive less heavy rains and are subject to dry seasons. The length of these dry seasons may also vary. Regions which receive light rains may receive them rather regularly at a certain season,

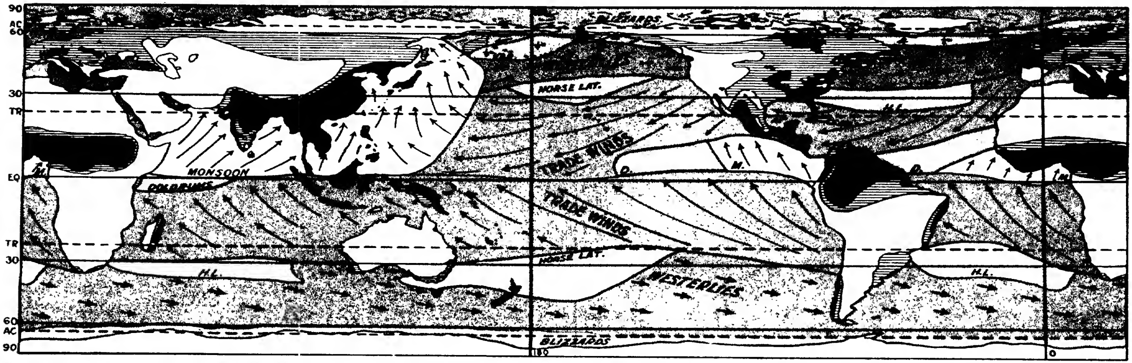
or else may receive them only occasionally, and may even remain dry during exceptional years. This shows that tropical Regions have a wide range of climates, and these climates are largely influenced by rainfall.

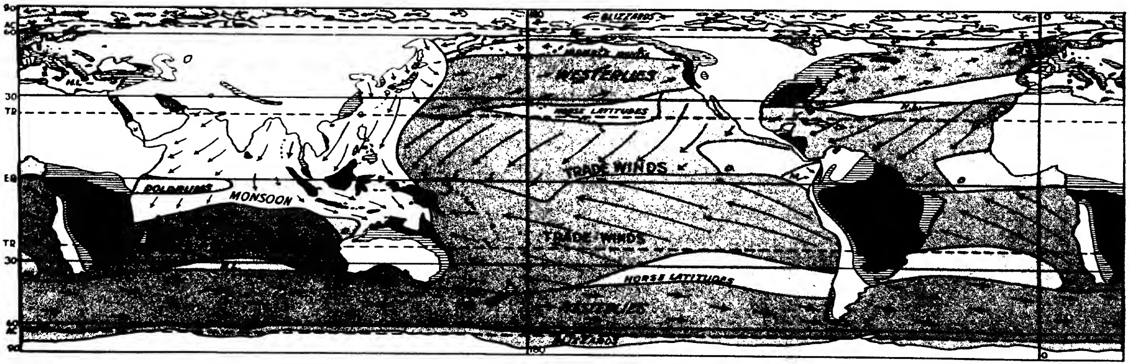
Middle-latitude Regions differ according to the position they occupy in respect of the great land masses of the World. Regions which are situated at the margin of these masses, that is, Regions which may be called coastal, have a more reliable climate than Regions which are situated farther inland and may be termed inland or continental.

The coastal Regions show a great difference according to whether they are situated on the western or on the eastern coast of the land masses. The Temperate West-coast Regions are influenced by westerly winds which bring most of the rainfall in winter (maps 3 and 4). The East-coast Regions are influenced by the trade-winds which bring most of the rainfall in summer (maps 3 and 4). Inland Regions may be subdivided into two groups. One group has light seasonal rains, namely, rains which fall rather regularly during certain seasons of the year; these are the Cool Grasslands. The other has erratic rains or practically no rains, conditions which create Cool Deserts.[7]

The high-latitude Regions which extend from about 42° to the poles cover a wider latitudinal range than any of the other groups of Regions. In such Regions temperature is a more important climatic factor than rainfall, and in this respect high-latitude Regions differ greatly from low-latitude Regions.

7. Koeppen's symbols: Temperate West-coast = *Cs*; East-coast = *Cw*, *Cfa*; Cool Grasslands = *Bsk*; Cool Deserts = *Bwk*.


90
AC
60
30
TR
EQ
TR
30
60
AC
90
MONSOON
DOLDRUMS
H.L.
HORSE LAT.
TRADE WINDS
TRADE WINDS
HORSE LAT.
WESTERLIES
BLIZZARDS
BLIZZARDS
180
0


90
AC
60
30
TR
EQ
TR
30
60
AC
90
BLIZZARDS
WESTERLIES
HORSE LATITUDES
TRADE WINDS
DOLDRUMS
MONSOON
TRADE WINDS
HORSE LATITUDES
180
0

Map 3.—WINDS AND RAINFALL IN JANUARY. This map is drawn on Lambert's cylindrical equal-area projection, which allows the World to be shown without any cut or interruption, and may be extended at will as has been done in this case to include a complete representation of the oceans. In this projection distances are true along the 30° parallels N. and S.
The wind belts are shown by different colours, names or initials being written in each case. The length of the arrows is proportioned to the regularity of the wind, and the thickness is proportioned to its speed (or "force"); the direction of the arrows shows the approximate direction in which the wind blows. Shaded land areas receive between 2 and 4 inches of rain during the month, black areas receive over 4 inches.

Map 4.—WINDS AND RAINFALL IN JULY. See explanation to map 3. A detailed comparison of the two maps is necessary in order to study the seasonal changes. The extent of the seasonal "swing" of the wind belts, and the close relation between winds and rainfall, are especially important.

FROM POLE TO POLE

ALONG A WESTERN COAST					ALONG AN EASTERN COAST			
Vegetation	Precipitation	Temperature	Climate	Latitude	Climate	Temperature	Precipitation	Vegetation
none / dwarfed	light	icy	ice-cap / tundra	90° 80° 70°	ice-cap / tundra	icy	light	none / dwarfed
conif. forest ..	light	cold	conif forest	60°	conif forest	cold	light	conif forest
mixed forest. ..	heavy	cool	*cool west-coast*	50°	cold east-coast		moderate	mixed forest
scrub woodland.	moderate	warm	*temp west-coast*	40° 30°	*temper east-coast*	warm	heavy	decid forest
grass / none	very light		*tropical desert.*	20°	*tropical forest*		very heavy	dense forest
parkland.......	moderate		savanna ...	10°	savanna ..		moderate	parkland
dense forest...	very heavy	hot ...	equator forest	0°	equator forest	hot	very heavy	dense forest
parkland.......	moderate.		savanna.. ..	10°	savanna		moderate	parkland
none / grass	very light.		*tropical desert..*	20° 30°	*tropical forest..* / *temper east-coast*	warm	very heavy. / heavy ..	dense forest / decid forest
mixed forest ..	heavy....	cool ..	(S America) *cool west-coast* (no land)	40° 50° 60°	(S America) *temper grassland* (no land)	cool / cold	light...	grassland
none..........	light. ..	icy.....	ice-cap	70° 80° 90°	ice-cap. ...	icy. ..	light.....	none

NOTE: (a) Whenever the wind belts cause the Regions on the western coast to differ from the Regions on the eastern coast at the same latitude, such Regions are shown in *different type*
(b) Temperature and rainfall as from yearly averages

or else may receive them only occasionally, and may even remain dry during exceptional years. This shows that tropical Regions have a wide range of climates, and these climates are largely influenced by rainfall.

Middle-latitude Regions differ according to the position they occupy in respect of the great land masses of the World. Regions which are situated at the margin of these masses, that is, Regions which may be called coastal, have a more reliable climate than Regions which are situated farther inland and may be termed inland or continental.

The coastal Regions show a great difference according to whether they are situated on the western or on the eastern coast of the land masses. The Temperate West-coast Regions are influenced by westerly winds which bring most of the rainfall in winter (maps 3 and 4). The East-coast Regions are influenced by the trade-winds which bring most of the rainfall in summer (maps 3 and 4). Inland Regions may be subdivided into two groups. One group has light seasonal rains, namely, rains which fall rather regularly during certain seasons of the year; these are the Cool Grasslands. The other has erratic rains or practically no rains, conditions which create Cool Deserts.[7]

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7. Koeppen's symbols: Temperate West-coast = *Cs;* East-coast = *Cw, Cfa;* Cool Grasslands = *Bsk;* Cool Deserts = *Bwk.*

The first distinction is between those high-latitude Regions which are cool or cold, and those which are icy. In cool or cold Regions plant life either goes on during the whole year or becomes dormant during the cold season; in the icy Regions some plant life may last during a very short season and then it dies out.

The first group of Regions includes the Cool oceanic West-coast Regions which enjoy a very short and generally mild winter, thanks to ocean currents and drifts. The Cold East-coast Regions at the same latitude are not so favourably influenced. They enjoy a rather warm summer, but winter is very long and low temperatures are recorded as a rule.[8]

Cold Coniferous-forest Regions[9] are removed from the moderating influence of ocean currents and from the influence of the ocean generally, and their climate is an extreme one in which winters are very long and very cold, and summers are short, although they may be warm and at times even hot.

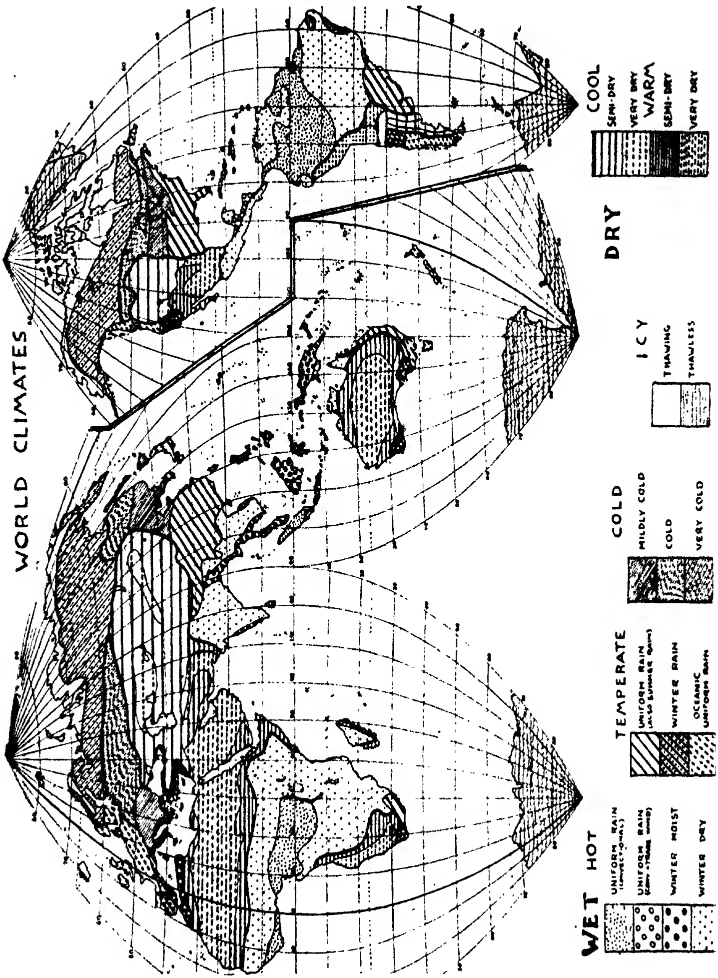
The icy Regions may be subdivided into two classes: in the Tundra Regions there is a season of thaw, some plant life may develop for a short time, and animal life may also exist. In those Regions which are always frozen there can be no ordinary plant life, and there is neither plant nor animal life on land, whereas their shores are visited in summer by migratory sea mammals and birds; these are the Ice-cap Regions.[10]

This general outline shows the great diversity of climatic Regions throughout the World. It

8. Symbols Cool oceanic west coast = *Cfb:* Cold east coast = *Da*.
9. Symbol *Db*, *Dc*, *Dd*.
10. Symbols -- Tundra = *ET*. Ice-cap = *EF*.

shows the great importance of latitude, but it also emphasises the deep influence exerted by rainfall and temperature. Perhaps the most important point is the value of rainfall in Regions where high temperatures prevail, as against the great significance of temperature in middle- and high-latitude Regions.

Although climatic Regions are usually given names which recall either the geographic location or the prevailing vegetation, it is possible to classify every climatic Region of the World purely from its climatic features. This system is not generally adopted, although it is definitely preferable (map 5).


WORLD CLIMATES
WET
HOT
UNIFORM RAIN
UNIFORM RAIN
WINTER MOIST
WINTER DRY
TEMPERATE
UNIFORM RAIN
WINTER RAIN
OCEANIC UNIFORM RAIN
COLD
MILDLY COLD
COLD
VERY COLD
ICY
THAWING
THAWLESS
DRY
COOL
SEMI-DRY
VERY DRY
WARM
SEMI-DRY
VERY DRY

Map 5.—THE REGIONS OF THE WORLD CLASSIFIED ACCORDING TO THEIR CLIMATIC FEATURES. The first classification of "wet" and "dry" zones is shown on map 1, the further classification into areas as determined by temperature is shown on map 2; the present map shows a further subdivision into climatic regions. A hot region may be said to receive a uniform rainfall only when the driest month gets over 2.4 inches of rain. When the driest month gets less than 2.4 inches the region is winter-moist only if the total yearly rainfall is high enough to balance the seasonal drought. Thus if the yearly total is over 50 inches, the driest month should get at least 1.94 inches in order to allow vegetation to continue; if the yearly total is over 90 inches, the driest month may get as little as .34 inches without reaching drought conditions. When the driest month does not get a sufficient rainfall, the region is said to be winter-dry. Among temperate regions, those are called oceanic, that have no month above 71.6°. In cold regions at least one month is below 26.6°; one may term "mildly cold" those cold regions where the warmest month is above 71.6° and "very cold" those cold regions where less than three months are above 50°. In icy thawing regions at least one month is above 32°.

Among "dry" regions, one may distinguish those that are semi-dry from those that are very dry. A region is semi-dry when its yearly rainfall is over one-half of what would be required to make the region "wet" according to the formulae given in the text. If the rainfall is less than one-half of what would be required to make the region "wet," the climate is very dry.
This scheme, adapted from Koeppen, enables the student to classify the climate of any place from the available meteorological records; needless to say, some practice is necessary before a certain skill is acquired.

III. THE LOW-LATITUDE REGIONS.

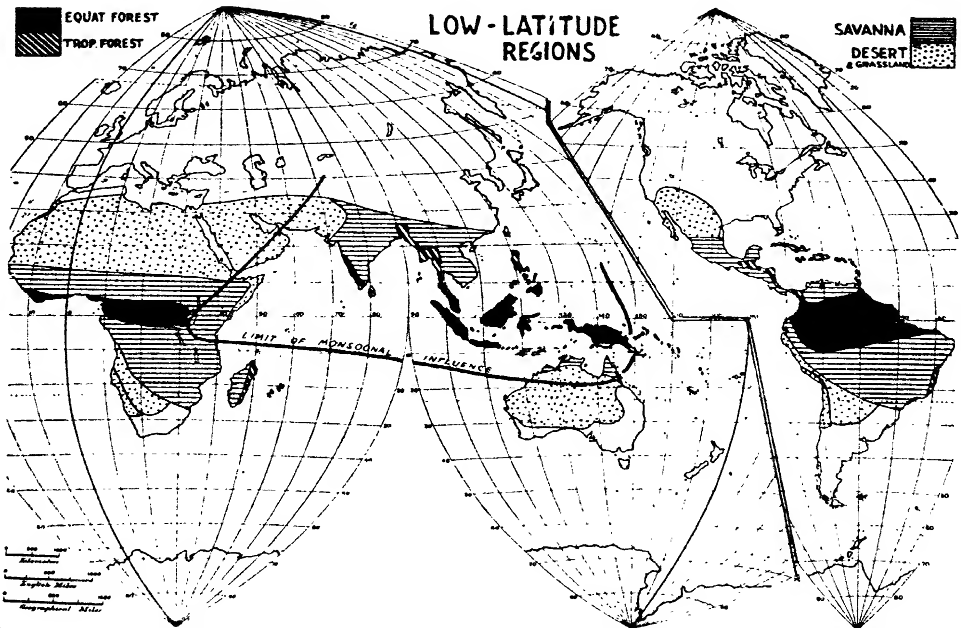
The two areas where the equatorial belt crosses large land masses are Africa and South America. In South America the equatorial belt includes practically one climatic Region, whereas in Africa the eastern section has a different climate from the western section, which is known as the Congo Basin. The equatorial belt also includes several islands of the Malay Archipelago and the southern half of the Malay Peninsula; these areas are situated between the two monsoon lands of Asia and Australia, and their climate is affected by the monsoons.

In these Regions rain is mainly caused by the rising of hot air, which cools at higher levels, and releases vapour which condenses and falls in heavy downpours. The higher the Sun in the sky, the more heat will be received by underlying lands, and the hotter their air will become. On March 21 and September 23 the Sun is seen overhead at the equator; the hottest temperature belt will be along the equator about six weeks later[1]. This causes air to rise and heavy rains to fall.

This type of rain, caused by the rising of hot air, is called convectional rain (fig. 1).

Two climates may be distinguished within the equatorial belt; the typical one is called Equatorial Forest Climate, and is bordered to the north and to the south by the second one, the Savanna Climate.

1 Our calendar is only approximate when astronomical dates are concerned, because of the difference between the calendar year and the solar year. The dates quoted are the most frequent ones; the greatest error occurs before each leap year.



Map 6.—LOW-LATITUDE REGIONS. The map is generalised and does not show highland climates as occur on the Andes, in the interior of New Guinea, Borneo and Sumatra, on the African Highlands, etc. The thick line shows the average limit of the influence of the Asiatic monsoons. The coastal strips of Desert climate in Western Morocco, South-West Africa, Northern Chile and Western Peru are temperate all the year round and on the map are separated from the main Desert Regions; their lower temperatures are due to cool ocean currents which skirt the coast.

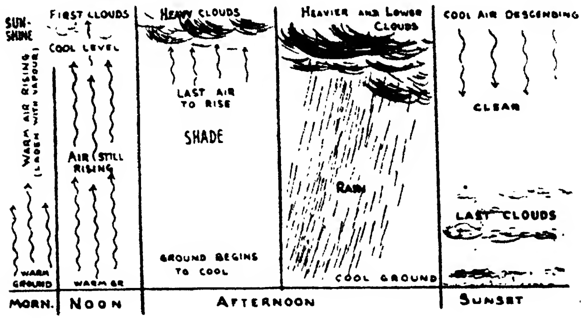


Fig. 1.—CONVECTIONAL RAIN. Typical convectional rain as shown here occurs in equatorial lands. In warm and in cold lands convectional rains are less regular.

EQUATORIAL FOREST CLIMATE: Within 6° from the Equator, with no month below 64.4°, no month with less than 2.4 inches of rain. (Koeppen's symbol *Afw.*)

Time	Temperature	Pressure	Winds	Humidity	Rainfall
June	hot	low	doldrums	high	heavy
December	hot	low	doldrums	high	heavy

This type of climate prevails in the Congo and Amazon Basins and all other Regions[1] shown black on map 6.

These Regions are very hot, and there is little difference in temperature between the seasons; actually one cannot speak of summer and winter, but only of two less wet seasons and two wetter seasons. There is much more difference in temperature between day and night than there is between a summer day and a winter day. It is always very wet and it rains very much, generally

1. The reader should use a good atlas in order to locate these areas in detail.

in very heavy downpours accompanied by violent thunderstorms. During the day, rains seem to follow the apparent position of the sun in the sky: clouds gather during the late morning, and storms break out in the afternoon. It rains regularly almost every day. There are no regular strong winds, as this type of climate occurs within the belt of equatorial calms or doldrums (fig. 2).

Monthly average temperature and average total rainfall for Singapore:

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	78	78	79	80	80	81	80	80	79	80	79	89
	Average 79, Range 3											
Rain . .	10	7	7	8	7	6	7	8	7	8	10	10
	Total 95.											

Soils of Equatorial-forest Regions are generally very deep and have lost some constituents through the heavy regular downpours; they have been altered by temperature, and are often red or yellow-red because of iron oxides (laterite soils, map 7*a*).

The persistently high temperature and the abundance of rain cause an extremely rich continuous plant growth. Hundreds of different plants battle for light and food within a limited space. The whole forest shows quite clearly several storeys. Creepers bind the whole forest by their winding stems, like ropes, ladders, festoons and aerial bridges. Orchids and other plants with aerial roots are very numerous.

Timbers are generally dark coloured and soft, plants exhibit surprising colours, flavours, smells —their resins, gums and oils are often very valuable.

the East African lands south of the equator (maps 3 and 4). Therefore the prevailing winds over the Masai Savanna blow from a south-westerly direction from June to September and bring dry conditions. The regular succession of rainy periods which is experienced over the Equatorial-forest Regions is interrupted over the Masai Savanna by this dry spell at this time of the year.[2]

The trade-winds are the "normal" wind factor affecting tropical Savanna Regions such as occur in tropical Africa and South America. In other areas they are offset and practically replaced by the monsoons; the two most important areas in this respect are South-eastern Asia and Northern Australia.

The importance of the tradewinds in all tropical Regions may well be understood by studying a World map showing distribution of the winds at typical periods of the year (maps 3 and 4).

In New Guinea, south of the mountains and along the southern coast, is an isolated area with a monsoonal Savanna climate. Farther south, beyond Torres Strait, is the Australian Savanna which extends far to the west, across the continent.

An example of such climate is afforded by Townsville (Q.):

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	81	81	80	77	72	69	67	69	72	77	79	81
	Average 75, Range 14.											
Rain . .	11	12	7	4	1	1	1	0	1	1	2	6
	Total 47.											

2 The height of the land plays an important role by lowering the average temperature, but the main feature of the Savanna, namely its long dry season, is due to the other factors mentioned above.

Rains come with the hot season, when the highest temperature belt swings away from the equator (map 3) and reaches those lands that during the rest of the year are under the influence of the tradewinds which are often very dry inland. During the short hot season, the doldrums belt brings its typical convectional thunderstorms to the African and South American tropical Savanna Regions; monsoonal winds are responsible for most of the rain which falls in summer over the corresponding Asiatic and Australian Regions. After a short hot wet season, the drought sets in.

Towards the wetter edge of the Savanna, trees grow almost close enough to form a forest; towards the drier edge there is a grassland with or without scattered trees; there are of course many intermediate types of vegetation. The typical feature of such climate is the length of the dry season, which kills the tall grasses and practically stops plant growth.

The Savanna of West Africa is the home of a coffee shrub. The Savanna of India yields ebony and teak; it is the home of the sugar cane, one species of cotton, and perhaps the banana.

TROPICAL FOREST CLIMATE: Latitude over 6°; no month below 64.4°, never as dry as the Savanna. (Koeppen's *Af*, *Am.*)

Season	Temper.	Pressure	Winds	Humidity	Rainfall
Summer	hot	1. low 2. high	onshore monsoon trades	high	heavy
Winter	1. hot 2. warm	high	offshore monsoon trades	low high	light heavy

1. Tropical Forest Regions under monsoonal influence, with some months receiving less than 2.4 inches rainfall (Koeppen's Am).
2. Tropical Forest Regions under trade-wind influence, with no month receiving less than 2.4 inches rainfall (Koeppen's Af).

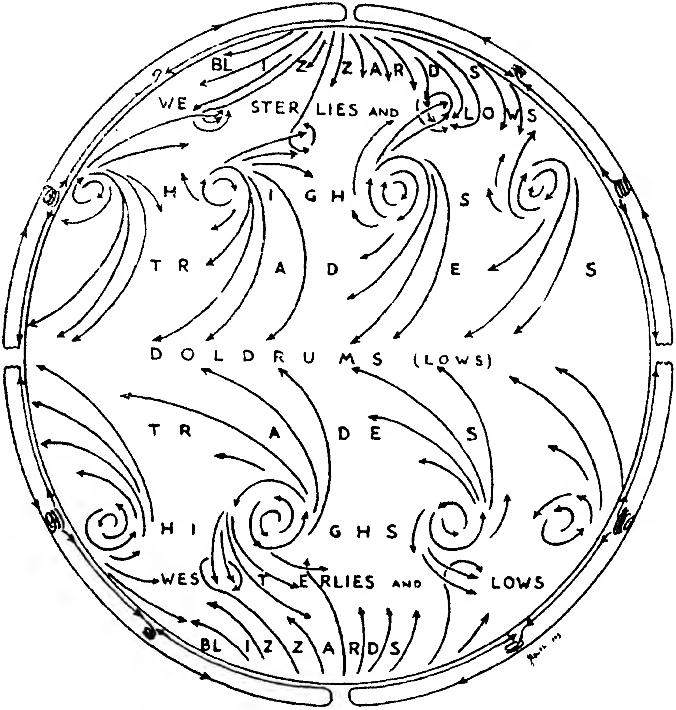


Fig. 2.—WORLD AIR CIRCULATION. Study in an elementary textbook the scheme of air circulation as it would occur on a motionless Earth. Examine a diagram showing the air circulation as it takes place when the winds are deflected by the rotating Earth. The actual World air circulation is complicated by the fact that the intervals between two successive highs are not quite regular, and those between two successive lows are definitely irregular; the relative position of highs and lows varies considerably. The present diagram shows the actual air circulation as it may be at any time, with highs and lows reasonably true to scale. Note the various stages in the formation of lows: top right (near S) before development; bottom centre (above ER) first stage, with the warm air spreading over the cold air; top centre (below R) second stage, with the warm air having already dragged the cold air into an ascending spiral motion; top right (before L) third stage, with the cold air having completed a turn of the spiral, thus intercepting the oncoming warm air (in technical terms, causing an occlusion). Intermediate stages may be seen. The latitude of the highs is more constant than that of the lows; highs and lows may vary in size and shape. Copy the diagram on a transparent paper and make it slide eastwards over a map of the World; also northwards and southwards to show the seasons.

This type of climate occurs at several favourably located places and permits the growth of dense forests at tropical latitudes (map 6).

Within the trade-wind belts (fig. 2, and maps 3 and 4) some eastern coasts and islands receive a heavy rainfall during most of the year.[3] Examples are the south-eastern coast of Brazil, the eastern coast of Madagascar, parts of Central America and the Antilles. On Mt. Waialeale, in Kauai (Hawaii Islands), the average rainfall reaches 460 inches a year, the highest yearly rainfall in the World.

The trade-wind tropical lands of Central America have given the World some extremely valuable plants, such as maize, sweet potato, pineapple, the species of tobacco now cultivated, vanilla; the best cedarwood was obtained from forests in the Antilles prior to the extinction of the trees, destroyed by ruthless exploitation.

There are very few places in Australia which have such a type of climate. Here are records for Innisfail in Queensland:—

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	80	79	78	75	71	68	67	67	71	74	77	79
	Average 74, Range 13.											
Rain . .	20	22	27	20	12	7	5	5	4	3	6	12
	Total 143.											

Other Regions receive a heavy summer rainfall brought by the onshore monsoon and are almost dry in winter; this happens in parts of India,

3 No wind is drying or rain-bearing in itself, its effect depends on whether the wind has just crossed a dry or a wet area. Thus the N.E. monsoon usually a drying wind, brings rain to Northern Ceylon after having crossed the Bay of Bengal. The trade-winds are drying in the interior of Australia, but they bring abundant rains to the eastern coast. See maps 3 and 4.

It is of course true that a wind blowing towards a relatively warmer area tends to absorb more water vapour, whereas a wind blowing towards a relatively colder area has its vapour-holding capacity reduced.

Ceylon, Burma and Malaya (map 6). Cherrapunji, in Assam (India), is a tiny village which receives the second highest rainfall in the World, 428 inches; June and July receive over 95 inches each, whereas December and January are almost rainless.

Forests which grow under monsoonal influence are not as dense as equatorial forests, and the seasonal drought makes most trees shed their leaves. The undergrowth is not very tall, there are fewer creepers, orchids and other aerial plants than in equatorial forests.

Assam is probably the home of the chief species of the tea shrub. Farther to the south-east, in Burma and Malaya, perhaps rice, bananas and one species of sugar-cane once grew wild; this Region is the home of teak and a species of rubber tree. Bamboo is one of the most useful plants growing wild in these lands. Still farther to the south-east, the Malay Archipelago has given the World sago and kapok, and the Moluccas precious spices.

In Australia this climate occurs on the eastern slope of the Atherton Tableland: these are the average records for Cairns, Queensland:

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	82	82	80	77	74	71	70	71	74	77	79	82
	Average 77, Range 12.											
Rain . .	16	15	18	11	4	3	2	2	2	2	4	9
	Total 88.											

TROPICAL DESERT CLIMATE: Yearly average above 64.4°; "dry" conditions (see Chapter II., and map 5). Koeppen's *BWh.*

Season	Temper.	Pressure	Winds	Humidity	Rainfall
Summer	hot	1. high 2. low	trades S.W. monsoon	low	none
Winter	warm	high	1. trades 2. N.E. monsoon	low	none

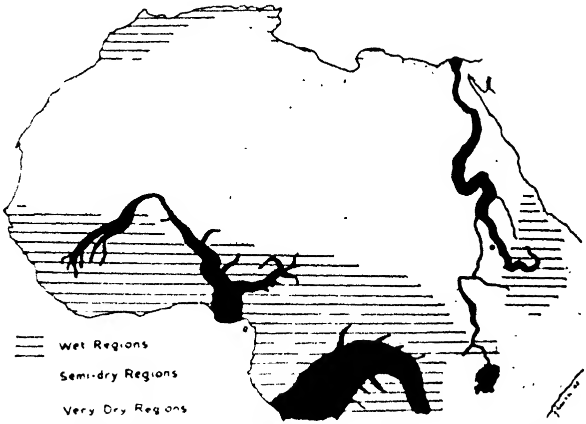
1. All tropical trade-wind deserts.
2. Thar monsoon desert (India).

Dry areas occur on the western side of every continent between about 15° and 30° N. and S. These areas are all within the belt of regular tradewinds (fig. 2). Australia may be taken as an example. The tradewinds blow onshore; therefore they bring rain to the coastline of Queensland and northern New South Wales. Once they have dropped most of their moisture in rising over the Great Dividing Range, they continue their way as dry winds. Farther on they have no chance of drawing up any more moisture from the dry lands over which they sweep, so that they end their course as extremely dry offshore winds in the North-West.

The main Tropical Desert Regions are the Sahara and Kalahari in Africa, the Thar in India, the Lake Eyre Depression in Australia, and all the country from there to the North-West, with the exception of the MacDonnell and Hamersley Ranges. In America there are two Regions: Sonora in North America, Atacama in South America (map 6). They all receive very little rainfall, and averages are most misleading.

Thus Arica in Chile received a total of 0.02 inches of rain in 17 years; Cossack in Western Australia received 9.16 inches in 1899, 40.03 in 1900, and 8.03 in 1901. And yet Cossack lies on the edge of the Desert Region.

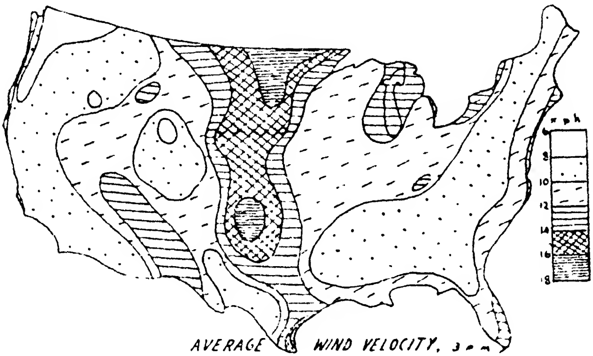
No permanent river has its source in Tropical Desert Regions. There are three great rivers running through such Regions, namely, the Nile, the Niger, and the Colorado; but they have their sources in Regions where rainfall is high and regular. They carry less water in the middle or lower parts of their courses where they cross the desert than they did farther up (map 8).



Map 8.—RIVERS AND CLIMATIC REGIONS IN NORTH AFRICA. The width of the rivers (not true to scale) is proportioned to the average quantity of water that flows. The Nile decreases the farther it goes into the very dry Hot Desert Region; the Niger decreases where it skirts the same Region, but increases afterwards. The Congo shows the normal flow pattern.

In Tropical Desert Regions it rains but seldom, and the amount which falls is quite unreliable. Occasionally there is a downpour sufficient to cause a flood, but this is followed by years of almost complete drought. The air is, of course, very dry, and clouds are rarely seen. As there

are no forests to slow them down, winds are sudden and violent (map 9) and carry always much dust which causes further erosion.[4]



Map 9.—AVERAGE WIND VELOCITY IN THE UNITED STATES. This map, reduced after the U.S.A. Atlas of Agriculture, shows how the highest wind velocities prevail over the grasslands and deserts, whereas forest and mountain areas have slower prevailing winds. It should be compared with maps showing the height of the land and the natural vegetation.

Marble Bar, in Western Australia, possibly is the hottest town in the World:

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	93	92	90	84	75	68	66	71	78	84	90	92
Average 82, Range 27.												
Rain . .	3	3	2	1	1	1	1	0	0	0	0	1
Total 13.												

Towards the margin of the Tropical Deserts some light rains fall every year. These marginal areas are usually known as Tropical Grasslands ("semi-dry" on map 5, Koeppen's *BShs*, *BShw*).

4 Desert conditions are well described in "The Secret of the Sahara: Kufara," by Rosita Forbes (Penguin Books).

Here are the recorded averages for Hall's Creek, W.A., where it rains in summer (Bshw):

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	86	85	83	78	71	66	64	69	76	83	87	87

Average 78, Range 23.

Rain . .	6	5	3	1	0	0	0	0	0	1	1	3

Total 20.

At Yalgoo, also in Western Australia, it rains when the belt of westerly winds has come near (winter, BShs), and grass is replaced by scrub:

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	84	83	78	71	61	56	54	56	61	66	75	81

Average 79, Range 30.

Rain . .	1	1	1	1	1	2	1	1	1	0	0	0

Total 10.

Most of these Tropical Desert Regions are not always plantless and some of them are temporary carpets of grasses and flowers after thunderstorms; but during most of the time they show patches of plants which have been adapted to dry conditions by reducing the number or the size of their leaves, or perhaps have lost them altogether. The roots of many of these plants penetrate the subsoil and the underlying rocks to depths disproportionate to the size of the plant, for example, the roots of mulga (acacia) shrubs barely 15 feet high have been observed at 70 feet below the surface. Conspicuously inflated trunks and leaves may store water, as many Mexican cacti do. There are, however, extensive desert areas which are covered by stone slabs or sandhills. A notable feature of some deserts is the oasis, which may be considered as an "island" of moister country surrounded by the great dry expanse of the desert.

The date palm is closely associated with human life in the Sahara, most of Arabia, and Iraq. The Arabs say that it grows with "its feet in the water and its head in the fire." Other useful plants of the Tropical Deserts of North and South Africa are acacias which yield gum arabic.

The Tropical Desert of Australia has similar acacias which yield tannin and gum; other plants such as saltbush and bluebush are of great pastoral value.

Some soils of the Desert Regions may be very fertile because they are not deprived of plant food by rainwater, but many desert soils lack vegetable matter and bacteria. The extreme example, desert sand, is possibly no longer a true soil, and certainly contains little organic matter and very little plant food. Desert soils are shown on map 7(i).

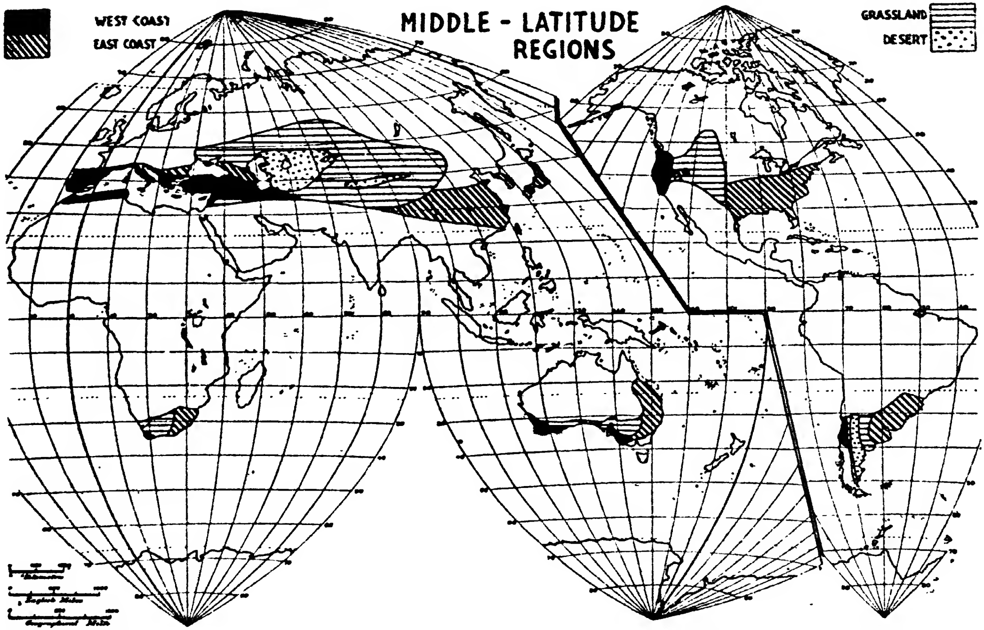
IV. THE MIDDLE-LATITUDE REGIONS.

The middle-latitude Regions which mostly lie between about 30° and 42° receive the Sun's rays at a moderate angle and are therefore temperate as a rule. Their summer may be almost tropical and their winter may be actually cold, but it is the average that matters in this case. It has been pointed out that there is a substantial difference between those Regions which extend near or on the coast of any land mass and those Regions which are located inland. The coastal Regions are milder in climate, and receive a better rainfall. The difference between West-coast Regions and East-coast Regions is mainly due to the prevailing winds.

TEMPERATE WEST-COAST CLIMATE: Coolest month below 64.4°, but above 26.6°; winter rain Koeppen's *Cs* (see Chapter II.).

Season	Temper.	Pressure	Winds	Humidity	Rainfall
Summer	hot	high	trades	low	none
Winter	cool	low	westerlies	high	moderate to heavy

West-coast Regions are influenced in winter by the westerly winds which carry along air eddies of immense size (fig. 2). Eddies whirling around high-pressure centres, where cool or cold air tends to descend, rotate clockwise in the Northern Hemisphere and anti-clockwise in the Southern Hemisphere. The opposite is true of eddies whirling around low pressure centres, where warm or hot air tends to rise. These low-pressure



Map 10.—MIDDLE LATITUDE REGIONS. Notice that West-coast Regions extend farther polewards than East-coast Regions; this is due to warm ocean drifts. The Adriatic Sea, the Black Sea and the Caspian have their own East-coast Regions. Grasslands and Deserts cover much larger areas in the Northern Hemisphere than in the Southern Hemisphere. The effect of continental masses, rain shadows and other factors should be studied in detail. The map is greatly simplified.

eddies, or cyclones, bring rain of a more regular type than that caused by the mere rising of hot air[1].

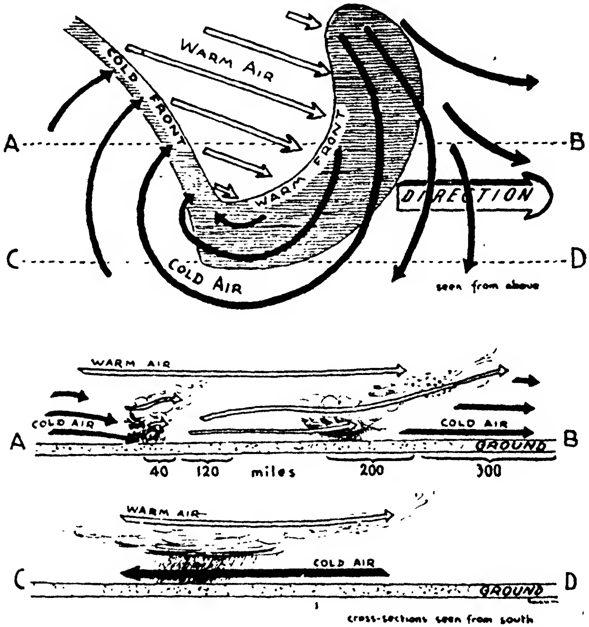


Fig. 3.—CYCLONIC RAIN. A cyclone shown as seen from above. It moves along carried by the westerlies in the direction shown by the large arrow, while it rotates as shown by the long thin arrows. Places where rain is likely to fall are shaded. In the section along A-B the cold and the warm fronts may be seen. Notice the various types of clouds, and the areas affected.

1 Needless to say, the terms *cold*, *cool*, *warm* and *hot* have a relative meaning. Thus air at 50° F. will be cool if the surrounding air or the underlying land reaches 70°, and almost cold if it reaches 100°. On the other hand, the same air at 50° would be uncomfortably warm if it suddenly swept over a frozen country. The south of Australia experiences low pressure in winter, and high pressure in summer; the South-West has its highest temperatures when there is high pressure over the Great Australian Bight.

It is rather difficult to explain how rain is caused by cyclones. The probable explanation—for the Southern Hemisphere—is outlined in fig. 3. Air coming from the south is cooler than air coming from the north. When the cyclone rotates, cold air is pushed northwards, and being denser and heavier than the warm air it finds in front of it, tends to lift it and to creep underneath. The warm air being so lifted is subject to quick cooling and—as happens in the case of convectional rains—drops some of its moisture content. The line along which this takes place is called the cold front. Rotating further, the cold air is warmed by the warmer surroundings, but still lifts the warm air. Farther east more warm air keeps on coming southwards, and in so doing, finds its way barred by other cold air. As warm air is thinner and lighter, its only course is to rise above the cold air which it cannot push or lift. In so doing it cools down, and releases some more moisture. The line along which warm air climbs over cold air is called the warm front.[1] Light clouds such as mare's tails are the forerunners of an oncoming cyclone, followed by mackerel sky, and later on by wool-pack and heavier clouds.

In summer, the trade-winds blow farther away from the equator and reach these Temperate West-coast Regions, thus making their summer very dry.

As rains fall in winter, they are most efficient because there is little evaporation during that season. On the other hand, even winter weather has many fine days, and cloudiness is seldom continuous or persistent.

1 This theory has been first formulated by Bjerknes in Norway.

Perth affords an excellent example of this climatic type:—

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	74	74	71	67	61	57	55	56	58	61	66	71
	Average 64, Range 19.											
Rain . .	0	0	1	2	5	6	7	6	4	2	1	1
	Total 35.											

In Adelaide the influence of the interior of the continent is felt, and winters are colder; rains are more evenly spread because of the more southerly latitude:

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	74	74	70	64	58	54	52	54	57	62	67	71
	Average 63, Range 22.											
Rain . .	1	1	1	2	3	3	3	2	2	1	1	1
	Total 21.											

In Europe this climate extends farther east than in any other continent. This is due to the prevailing east-west setting of Spanish mountains which therefore do not act as a great climatic barrier. Once the cyclones have passed over Spain, they pick up more moisture over the Western Mediterranean, and bring more rain to Sardinia and Southern Italy. More moisture from the Ionian Sea is brought to Greece, and, farther over the Aegean Sea, to Turkey. The last moisture picked up from the Eastern Mediterranean is dropped over Syria and Palestine (map 10).

In North America, one must look at a map showing the mountains of California to understand why this climate is limited to such a small area. Conditions in Chile are quite similar. In South Africa and Australia the climate does not reach its full extent because both continents have the western coast "cut off" at about 35° S.

Victoria is the meeting point of three climates, one with winter rain in the west, and two with uniform rain in the east.

In Temperate West-coast Regions with winter rain, woodlands are often rather open with a thick scrubby undergrowth. Among nature's devices against excessive evaporation during the dry summer, are the coating of leaves with waxy or leathery layers, or the formation of bulbs, tubers and rootstocks to be used as a store of food and moisture. Man first developed agriculture in such an environment, and made use of these peculiarities of the native flora. Winter-rain floras, besides their value to man, are characterised by the dullness of their green and their great wealth of scents.

One of the best examples of adjustment to seasonal drought is afforded by the cork oak: it develops an extremely thick bark which is the substance usually known as "cork." The tree grows in Western Mediterranean lands. Other trees valued for their timber and for ornamental purposes are cedars—still numerous in the Atlas, very rare in the Lebanon—cypresses, and pines. Many gardens display oleanders and small palms which come also from the European Mediterranean. Figs, apricots, almonds, walnuts, chestnuts, black mulberries all grow wild in some of the Eastern Mediterranean lands. The most typical Mediterranean tree is perhaps the olive tree, now less important to man than in olden times. The wealth of scented shrubs is great: roses, myrtle, rosemary, thyme, lavender are the best known. Several cultivated rootstocks were certainly known around the Mediterranean very long ago;

perhaps even barley and hard wheat had their origin there.

Agricultural development has reached the corresponding Regions of other continents quite recently, and man has not yet learned to utilise local plants. The fact that those Regions are much smaller than the European West-coast Region may also explain their lesser plant wealth. One must, however, mention the great value of Western Australian timbers such as jarrah and karri, and the blackboy which is perhaps the richest plant in useful chemical substances.

Most soils of these Regions are affected by the heavy winter rains, which leach and carry away valuable elements. Temperature is here less important than rainfall so far as soil formation is concerned. These soils are shown on map 7 (*c*). Along the drier boundary of these Regions there are red-brown earths which do not differ greatly from the rich black earths formed under different conditions, as found near the Cool Grasslands which will be described later on.

TEMPERATE EAST-COAST CLIMATE: Coolest month below 64.4°, but above 26.6°; hottest month above 71.6°; uniform rain or winter drought. (Koeppen's *Cfa, Cw.*)

Season	Temper.	Pressure	Winds	Humidity	Rainfall
Summer	hot	high	trades	high	heavy
Winter	cool	low	trades and westerlies	moderate	moderate

The Temperate East-coast Regions being at about the same latitude as the Temperate West-coast Regions are also affected by the tradewinds in summer, but because of their eastern

aspect they receive a rather heavy summer rainfall, while the Temperate West-coast Regions are dry. In winter these East-coast Regions receive only little rainfall from the cyclones because much of the moisture load has already been dropped over the West-coast Regions; more winter rain is brought by the tradewinds.

Another substantial difference between West-coast and East-coast Regions is due to the influence of ocean currents. Relatively cool currents move towards the equator and tend to make the West-coast Regions drier than they would otherwise be; relatively warm currents move towards the poles and tend to make the East-coast Regions wetter than they would otherwise be.

These Regions have a rainy climate, with very variable rainfall. Temperatures are also occasionally variable, in winter the tradewinds have retired nearer to the equator, and some East-coast Regions are swept by the winter (offshore) monsoon, very cold and dry. It follows that summer is generally warm and moist, and winter may be bitterly cold occasionally. This is a type of climate where averages may be misleading so far as rainfall and temperature are concerned. Agriculture is always in danger from frosts, which are perhaps more harmful where they are less frequent, because no measure is taken to protect crops.

This type of climate prevails over most of Southern China, Japan, south-eastern Queensland and eastern New South Wales, south-eastern United States, and South America east of the Uruguay River. Minor Regions are Natal in South Africa, and Batum in Soviet Georgia. All

these Regions are shown on map 10.

Here are averages for Brisbane:—

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	77	76	74	70	65	60	59	60	65	70	74	76
	Average 69, Range 18.											
Rain . .	6	6	5	4	3	3	2	2	2	3	4	5
	Total 45.											

One may compare with Sydney, which has the same type of climate:—

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	72	71	69	65	59	54	52	55	59	63	67	70
	Average 63, Range 20.											
Rain . .	4	4	5	6	5	5	4	3	3	3	3	3
	Total 48.											

Broadleaved trees dominate forest formations in Temperate East-coast Regions, and only towards the cooler margins are they mixed with coniferous (needle-leaved) trees. There are, however, some kinds of pine which grow and form even extensive forests in the warm parts of Temperate Regions. Broadleaved trees are generally deciduous, but in some areas they may keep their leaves; this is the case for instance in Australia with eucalypts. In cooler areas, the widespread leaf shedding gives autumn shades and colours which are absent in warmer areas. The rather humid climate and the moist environment brought forth by summer rains favour growth of very many plants, and man owes to these Regions some of the best fruit trees and some of the finest ornamental shrubs, now fully acclimatised elsewhere. On the other hand, agriculture has completely destroyed the natural vegetation over most of the Chinese East-coast Region, except on the mountains of the interior.

The camelia and the wistaria, the orange and perhaps the peach, the green mulberry and the soya bean are natives of China. At least one type of mandarin has its origin in southern Japan.

The corresponding Region in eastern Australia is famous for its wealth of beautiful timbers. South America is the home of maté (*matè*) whose leaves are used like tea leaves. Before their destruction, North American broadleaved forests contained valuable timbers, and beautiful shrubs.

Soils of the East-coast Regions have been deprived of some constituents by the heavy rains, and are often reddish or yellowish because of alterations due to temperature. These soils are valuable for agriculture only when manuring is regularly practised; they are shown together with the soils of the West-coast Regions on Map 7 (*c*).

COOL GRASSLAND CLIMATE: Yearly average below 64.4°; "semi-dry" conditions (see map 5). Koeppen's symbol, *BSk*.

Season	Temper.	Pressure	Winds	Humidity	Rainfall
Summer	warm	low	1. Westerlies 2. Variable	low	light
Winter	cold	high	1. Westerlies 2. Variable	low	1. light 2. none

1. North and South America.
2. Asia.

Under winter rainfall typical grasslands are replaced by scrublands; this is especially noticeable in Western Australia.

This climate may be due to either the distance from the ocean or to the shelter afforded by very high mountains (rain shadow, fig. 4).

Mildura, in Victoria, has a Cool Grassland climate—

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	77	77	70	63	56	51	50	53	58	64	70	74

Average 63, Range 27.

Rain . .	0	1	1	1	1	1	1	1	1	1	1	1

Total 11.

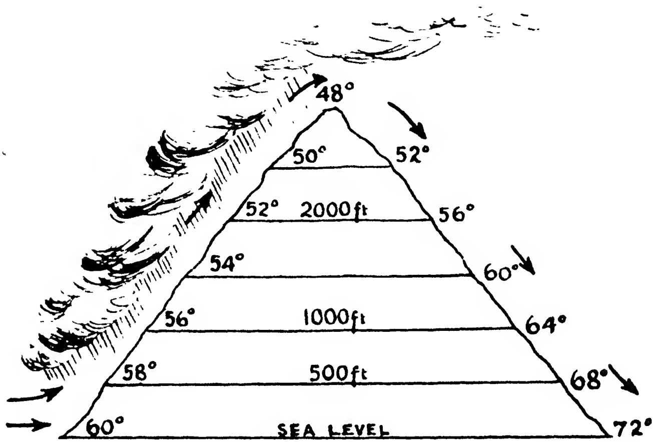
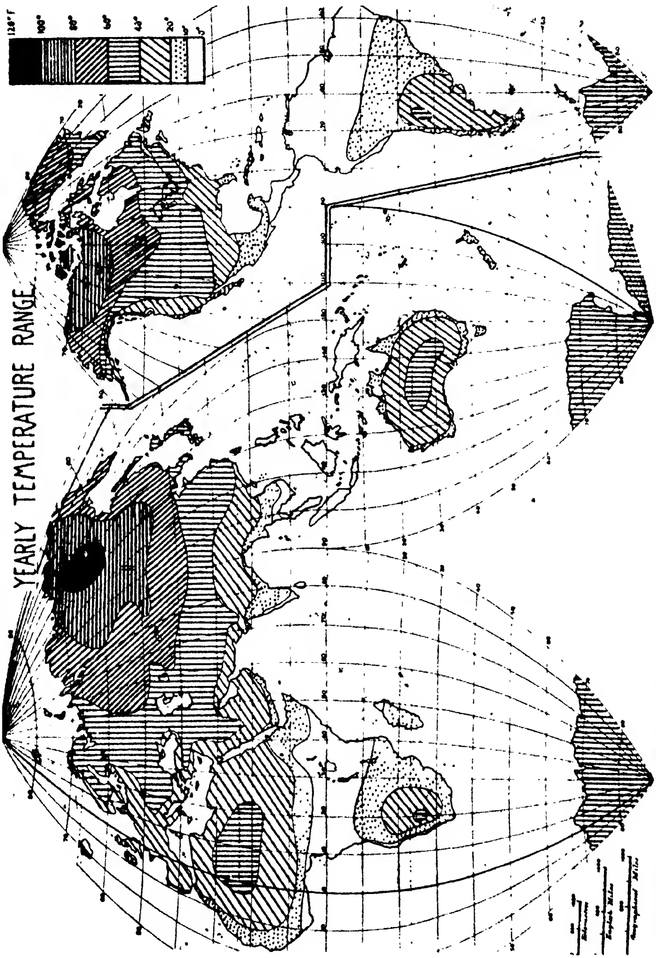


Fig. 4.—RELIEF RAIN. A diagram to show how a wind which is forced to climb a slope cools down and releases some of its moisture as rain. While climbing the temperature falls at a rate of 1° F. every 250 feet. On the leeward side the dry air descending from the summit warms up at a much faster rate, 1° F. every 140 feet. This is the origin of the warm dry winds which are known as Foehn (foen) in Central Europe and Chinook in Canada.

In Asia, Cool Grassland Regions are very far from the ocean, and ranges are extreme (map 11). It is in Asia that these grasslands cover the most extensive areas, extending from Mongolia to the highlands of Tibet and Iran; areas north of the Caucasus and as far west as the Black Sea have also this climate (map 10).

In North America, the lands immediately to the east of the Rocky Mountains have this grass-



Map 11.—YEARLY TEMPERATURE RANGE. The limited ranges experienced near the equator and near the coast compared with the great temperature ranges of the interior of large continents.

land climate, which occurs also in small areas between the Rocky Mountains and the Cascade Range. In South America there are Cool Grasslands east of the Andes in Southern Argentina. Both the North American and the South American Cool Grassland Regions are within the rain shadow of the high mountain ranges, the Cascade Range and the Rocky Mountains in the case of North America, and the Andes in the case of South America.

Whereas most Cool Grasslands of Eurasia[2] owe their existence to the great distance from the ocean, Tibet has a similar climate because it comes within the rain shadow of the Himalayas in summer, when the onshore monsoon blows.

There are some soil types which are found at the wetter margin of these Grassland Regions, forming a sort of intermediate belt. Such are the black earths (map 7, *g*) found near the wetter margins where it rains in spring and summer. The great agricultural value of black earths is due to their receiving much plant food from grass roots which are decomposed by bacteria very soon after the first rains begin. As it rains mainly during the warm season, bacteria are very active, helped also by the warm sunshine which is not intercepted by trees. It never rains too much, and plant foods are left very near the surface. Prairie soils form on grasslands under slightly wetter conditions (map 7, *d*).

2. This term is used to signify the Asiatic-European land mass, which is climatically continuous.

COOL DESERT CLIMATE: Yearly average below 64.4°; "dry" conditions (see map 5 and Chap. II, Koeppen's symbol *BWk*).

Season	Temper.	Pressure	Winds	Humidity	Rainfall
Summer	warm	low	variable	low	none
Winter	cold	high	variable	low	none

Some Cool Deserts are found in the interior of large continents, very far from the ocean, as in the case of the Gobi Desert and the lands north of Lake Aral. In North America there are small patches of Cool Desert in the rain shadow of the Cascade Range. In South America the Patagonian Desert lies, surrounded by grasslands, in the rain shadow of the Southern Andes. There is hardly any area with such a climate in Australia, but for a very narrow strip along the transcontinental railway, which seldom receives any rain (map 10).

Cook, in South Australia, lies within this Cool Desert strip:

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	71	73	70	64	57	51	50	54	58	63	70	72

Average 63, Range 23.

Rain . .	0	1	0	0	1	1	0	1	0	0	0	1

Total 5.

The vicinity of the ocean has a moderating influence and there is relatively little difference between summer and winter temperatures, when compared with the conditions which prevail in the Cool Deserts of other continents.

Cool Desert Regions have a rather poor vegetation, subject to the vagaries of the rainfall. Plant life is not only limited by the dryness of

the climate, but also by the cold season which lasts long enough to kill most small plants.

Cool desert soils are rather poor in plant food and lack organic matter and bacterial life; where irrigation is possible, excellent results are sometimes obtained (map 7, *i*).

V. THE HIGH-LATITUDE REGIONS.

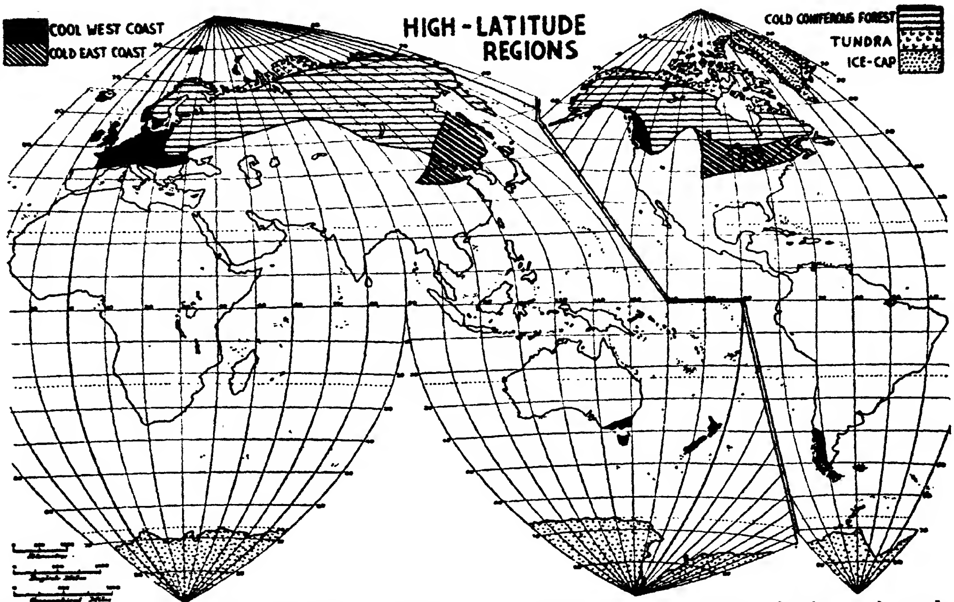
It has been already explained that since these Regions extend 48° of latitude in each hemisphere they vary greatly in respect of temperature. This is only one of the features of such Regions, the duration of daylight being another very important characteristic.

COOL WEST-COAST CLIMATE: Warmest month below 71.6°; coldest month above 26.6°; uniform rain. (Koeppen's *Cfh.*)

Season	Temper.	Pressure	Winds	Humidity	Rainfall
Summer	cool	low	westerlies	high	moderate
Winter	cool	low	westerlies	high	moderate to heavy

The West-coast areas enjoy a cool climate and are seldom subject to extremes of cold; the other Regions in high latitudes are cold or icy. The difference between the coolness of the West-coast Regions and the coldness of the East-coast Regions found at the same latitude is due to ocean currents. In North-Western Europe the ocean drift which is the continuation of the Gulf Stream across the Atlantic makes temperatures much higher than they would otherwise be. In British Columbia and South Alaska the same effect is due to the drift which is the continuation of the Kuro-Siwo across the Pacific.

The largest continuous area enjoying such a climate is Western Europe; this is due to the rather low build of the country, and to the beneficial influence of the Gulf-Stream drift. In North



Map 12.—HIGH-LATITUDE REGIONS. Cool-West-coast Regions extend much farther polewards than Cold East-coast Regions, because of warm, ocean drifts. Notice how in Iceland and in Tierra del Fuego Cool West-coast Regions merge with Tundra Regions without any intermediate belt. Because of the shape of Australia, the Cool West-coast climate occurs in the South-East. Draw a map in which Australia is shifted 20° further south and divide this "high-latitude Australia" into climatic Regions; the Cool West-coast Region will then be shown on the western coast. The map is greatly simplified.

America the Rocky Mountains limit this climate to the coast; the influence of the Kuro-Siwo drift is nearly as good as that of the Gulf-Stream drift in Europe. In South America this climate is found in Southern Chile (map 12).

In Australia this type of climate occurs in Southern Victoria, where it is not, however, well defined. Tasmania and New Zealand are excellent examples, with cool summers, cool winters, and high rainfall up to 110 inches in the wettest area of Tasmania, and over 200 inches on the slopes of some mountains in Southern New Zealand.

Hobart has the following set of average records.

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	62	62	59	55	51	47	46	48	51	54	57	60

Average 54, Range 16.

Rain . .	2	1	2	2	2	2	2	2	2	2	3	2

Total 24.

Melbourne is not a very good example of this climate because of the general direction of the coastline, which is not apt to "catch" rains coming from the west:

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	67	68	65	59	54	50	49	51	54	58	61	65

Average 59, Range 19.

Rain . .	2	2	2	2	2	2	2	2	2	3	2	2

Total 25.

The climate of Cool West-coast Regions is influenced mainly by a succession of cyclones moving eastward. There are frequent light rains, often mist and fog, and swift changes from cloudiness to sunshine. Thunderstorms are never frequent and occur mainly in summer. This climate is chiefly found where east-bound cyclones meet a

coastline. If the coastline is low, as in Western Europe, the cyclones will drop some rain, but will also retain some, and will carry it farther inland. If the coastline is high as is the case in British Columbia and Southern Alaska, so much rain is dropped that the cyclones are seldom rain-bearing after they have crossed farther east (fig. 4).

In these Regions forests are seldom dense, and shed their leaves in autumn; this favours a varied undergrowth of shrubs and grasses. The relative cold of some districts favours the development of grass formations such as meadows and moors, and even mixed moss formations as in some bogs, with consequent deposition of peat. Conifers are rather numerous particularly near the cooler margins of these Regions, and often predominate. The West-coast Region of North America is an exception, because it has no broadleaved trees, and is covered only by needle-leaved trees.

Europe has gradually exhausted most of its mixed forests. Its most valuable hardwoods, namely oak and beech, are still preserved over limited areas. Man has learned to utilise small trees and shrubs which are quite frequent in some districts, for instance medlars, hazels, brambles and junipers. The chief product man draws from these Regions is, however, timber: various species of beech in Europe, Chile, Victoria, Tasmania and New Zealand; various species of pine in Europe, Chile, Tasmania and New Zealand; spruces and firs in British Columbia, Washington and Oregon.

In Cool West-coast Regions soils are enriched by large quantities of leaves which fall every winter, but the persistent rains deprive them of

some valuable plant food. These soils, which are greyish or brownish in colour, are shown on map 7 (*e*).

COLD EAST-COAST CLIMATE: More than three months above 50°; coldest month below 26.6°.[1] (Koeppen's *Da.*)

Season	Temper.	Pressure	Winds	Humidity	Rainfall
Summer	cool	low	variable	moderate	light
Winter	cold	variable	variable	moderate	light

In this climate plant growth has to cease during several months, and the soil is frozen for at least a month.

The Cold East-coast Regions are reached by the westerly winds and the cyclones after a long journey over continental masses or, in the case of South America, over the very high Andes; the rainfall they receive is moderate and quite variable. It may be added that cold currents such as the Labrador current of North-East America and the Kurile current of North-Eastern Asia make the East-coast Regions even colder than they would otherwise be.

The conditions in these Regions favour quick-growing crops. However, spring and autumn frosts frequently cause great damage. Early heat waves may also be harmful. Winters always bring snow, but a great part of winter precipitation is in the form of rain. Summers are rather wet, and most of the rain is due to convection because the ground is frequently heated, and air tends to rise. These mild moist summers are of the greatest value for crops. Rain and snow in

1. This definition is simplified.

winter are mainly brought about by cyclones passing over the country. The peculiar result of these conditions is that, although there are more clouds in winter, precipitation is heavier in summer.

Here are records for Winnipeg, the great wheat centre of Manitoba—

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp.	–4	0	15	38	52	62	66	64	54	41	21	6
	Average 35, Range 70.											
Rain . .	1	1	1	2	2	3	3	2	2	1	1	1
	Total 20.											

In Asia this climate is found in the Amur Basin, Manchuria and Korea; these areas are under the influence of the large continental mass, and their temperatures are therefore variable. The same is true of the American Cold East-coast Region which extends from the Middle West and the Great Lakes to the mouth of the Saint Lawrence (map 12).

Prior to agricultural settlement Cold East-coast Regions were covered by a mixed forest, in which broadleaved trees dominated, and coniferous trees were more conspicuous near the poleward margins. In Europe there was little difference from the plant life of the Cool West-coast Region. In North America, on the contrary, the Cold East-coast Region has those broadleaved hardwoods which are missing in the corresponding Cool West-coast Region. Humidity and low temperatures at places favour the formation of bogs and marshes.

Central Europe is possibly the home of the cherry tree and the flax and hemp plants. The corresponding North American Region has about a score of wild vines, of which at least three be-

came of vital importance to European vignerons when their plants died from imported parasites and diseases; American vines resisted these enemies very well, and were therefore planted in Europe, and grafted with European vine scions.

American and Asiatic forests show an amazing timber wealth, including many species of oak, chestnut, walnut, maple, ash, elm, hickory, and other stately trees.

The soils of these Regions do not differ considerably from those of Cool West-coast Regions; large quantities of leaves fall in winter and provide plenty of humus, but frost and the permanence of water after the first spring thaw leach useful plant food into the subsoil (map 7*e*).

COLD CONIFEROUS FOREST CLIMATE: Between one and three months above 50° [2]; coldest month below 26.6° (Koeppen's *Db*, *Dc*, *Dd*).[2]

Season	Temper.	Pressure	Winds	Humidity	Precipit.
Summer	cool	low	variable	moderate	light
Winter	icy	high	variable	moderate	light

This climate extends from the Atlantic to the Pacific across northern Eurasia, and from the Pacific to the Atlantic across northern North America. It is the only climate surrounding the whole World in an almost continuous ring (map 12). Summer is very short, lasting less than three months. Trees grow, although very slowly; grasses and mosses live their whole life-cycle in this short time. The shortness of summer is partly balanced by the relatively easy warming-up of the large continental masses, and by the

2. This definition is simplified.

very long period of daylight. Conversely, winters are very long, and colder even than in cooler areas, because the ground cools down very rapidly in the heart of such large continents. Since midsummer is rather warm, the yearly range of temperature is amazing (map 11). Verkhoyansk in north-eastern Siberia once recorded —90°; and yet, it is a small permanently inhabited village.

These Regions are not generally very wet, and most of their precipitation is in the form of snow, which reaches often several feet of depth.[3] In summer there are light rains from rising warm air. Such rains would be absolutely insufficient in any warmer climate, but in these cold Regions evaporation is so slow, that they are not only enough, but cause even waterlogging at times. Although winter is bitterly cold, and winter nights are very long, or even continuous in the far north, the sky is usually clear. Windstorms are frequent in winter because of the great difference in the density of the air between these Regions and the less cold surrounding areas.

Here are records for Verkhoyansk, the coldest village in the World.

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp.	-58	-48	-22	8	35	54	59	51	36	6	-34	-52

Average 3, Range 117.

Rain	0	0	0	0	1	1	1	1	0	0	0	0

Total 4.

(Actually some rain or snow is recorded during every month but March; it is too little to be shown above; the yearly total given is correct.)

Throughout these Regions the coniferous forest is dominant. Since needle-leaved trees are gener-

3. It is generally reckoned that one foot of snow equals one inch of rain.

ally evergreen, there is little light and air for any undergrowth. Near lakes and rivers are groves of broadleaved trees belonging to a few cold-resisting species. Tree growth is generally slow because of the short mild season; and excessive cold often makes the trees stunted and thin. While in warmer Regions it is usual to find several different species of trees, forests in these cold Regions are generally formed by very few species. Bogs and marshes become an important feature in the landscape, and peat is found over hundreds of square miles and several feet deep.

Scandinavian forests generally contain spruce, larch and pine, while birch and alder are the representatives of broadleaf trees. Siberian forests have other kinds of larch and spruce, and farther east mainly fir and pine. Canadian forests contain also several species of spruce, fir and pine.

Soils are sour and have been subject to excessive leaching, because of low evaporation and melted snow; they are of poor agricultural value at present and only few crops can be grown on them. These soils are often ash-grey in colour; they are shown on map 7 (*f*).

TUNDRA CLIMATE: No month above 50°, but at least one month above 32°. (Koeppen's *ET.*)

Season	Temper.	Pressure	Winds	Humidity	Precipit.
Summer	cold	variable	variable	moderate	light
Winter	icy	variable	variable	moderate	light

All climates studied until now, allow some tree growth. Icy climates are too cold even in summer to allow any tree growth. This does not mean that there is no life at all; it is only limited to

a very short season, and is subject to many other limitations.

In Tundra Regions a short thaw occurs. This enables dwarfed plants to grow, and some animal life may subsist on the scanty vegetation. Although the soil thaws for a certain period, the subsoil is always frozen. The air is always dry, and the little precipitation is practically all snow. This climate is found along the northern edges of Eurasia and North America, along the southern edge of Greenland, and in the islands south of Patagonia and the Falklands (map 12)[1].

This is the climate of Upernivik, a tiny village in western Greenland.

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp.	-7	-10	-6	6	25	35	41	41	33	25	11	1

Average 16, Range 51.

Rain . .	0	0	1	1	1	1	1	1	1	1	1	0

Total 9.

ICE-CAP CLIMATE: No month above 32 (in Koeppen's symbols *EF*).

Season	Temper.	Pressure	Winds	Humidity	Precipit.
Summer	icy	high	blizzards	generally high	variable
Winter	icy	high	blizzards	generally low	variable

In Ice-cap Regions no thaw occurs and practically no higher plant life is possible in the land. Along the coast migrant animals come in summer to prey on marine life. There are only few records brought back by explorers from these Regions, and averages based on such short periods of observations are not reliable.

1 The tundra of Labrador is described by J. M. Scott in "The Land that God gave Cain"; Greenland is described by M. Lindsay in "Sledge" and "Those Greenland Days" (all Penguin Books).

The following records were obtained by an Australian expedition at Cape Denison, Antarctica:—

	Jan.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Temp. .	30	24	12	2	0	-4	-4	0	-1	5	18	27

Average 9, Range 34.

Rain . .	0	1	8	14	13	2	4	9	5	2	1	0

Total 59.

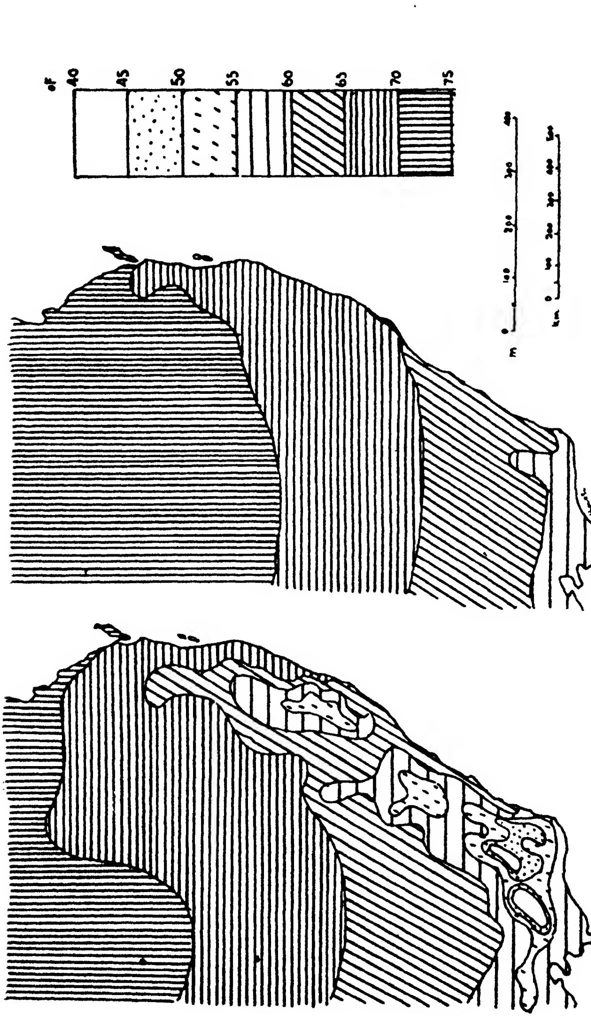
The Ice-cap Regions extend over the whole of Antarctica, the Greenland Plateau, the eastern part of the Svalbard (maps 12 and 15).

VI. THE HIGHLAND CLIMATES.

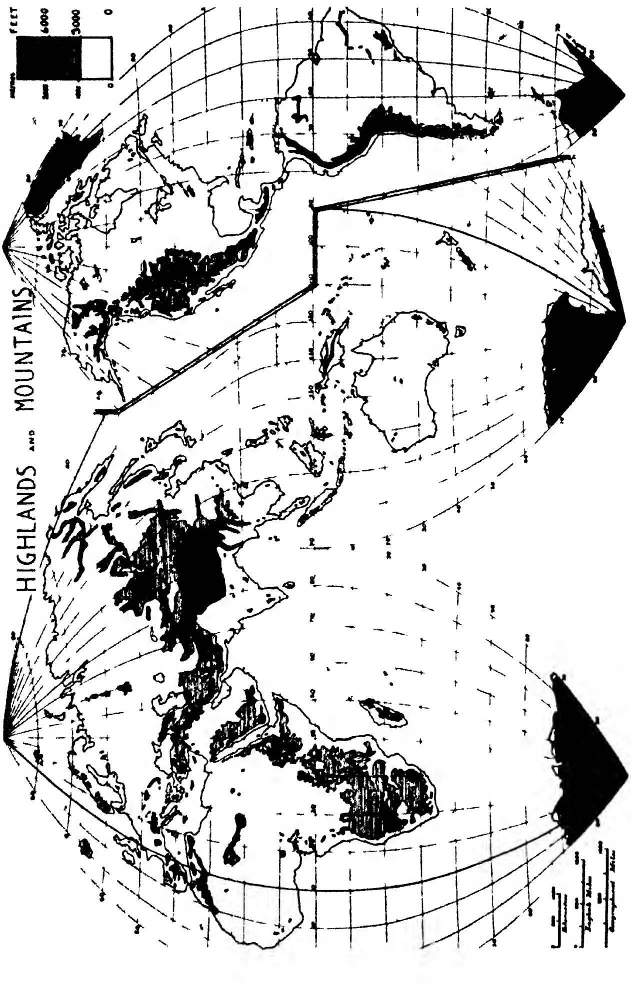
The preceding chapters describe climates which are distributed rather regularly on the Earth's surface. The general pattern is in the main determined by latitude, and affected by other factors, such as size of land masses, presence of mountain barriers, influence of sea currents. The main effect of latitude is perhaps a change of temperature: the nearer the poles, the lower the average temperature—there are of course exceptions, but this may be taken as a general rule.

For several reasons, temperature tends to fall in the higher levels of the atmosphere, so that in climbing a mountain, one reaches cooler and cooler air, until at the limit of permanent snow, freezing point is reached. This does not mean that it may not be warm at the same time: lighter, thinner air does not absorb and transmit heat like heavier, denser air does. On a high mountain therefore sunshine may be very warm, and yet in the shade it may be still cold, and on the ground there may be a continuous cover of snow. These temperature contrasts, together with the purity of the air and the scarcity of microbes, make mountain excursions generally very healthy and invigorating.

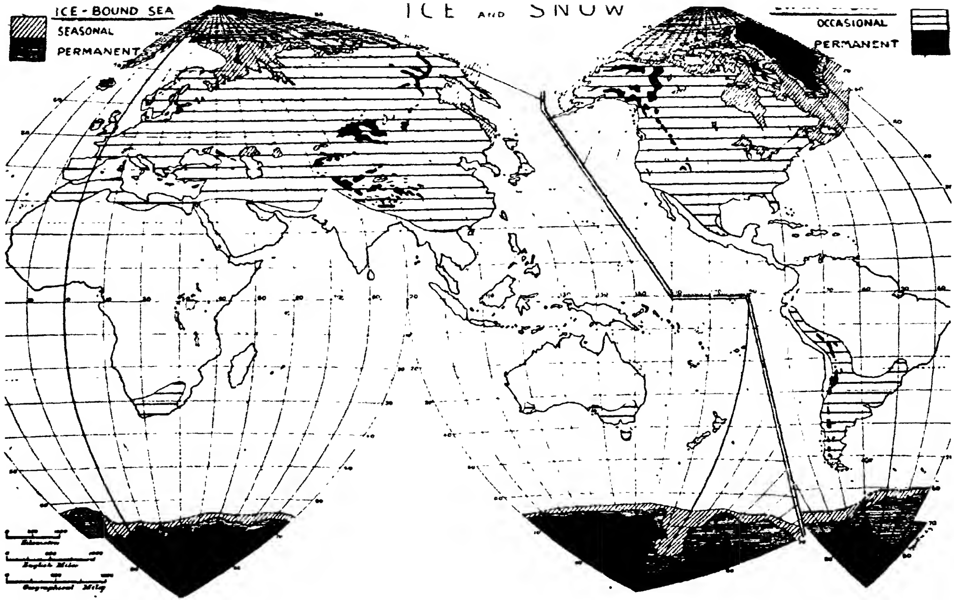
The fall in temperature experienced while climbing varies between 3° and 5° for every 1000 feet. Usually, to reduce the temperature of any place which is above sea level, to what it would be at sea level, an addition of 1° for every 300 feet is made. "Reduced" temperatures are not



Map 13.—ACTUAL AND REDUCED YEARLY AVERAGE TEMPERATURES, EASTERN AUSTRALIA. The height of the ground above sea level clearly appears in the map to the left (adapted from the Commonwealth Meteorologist's Climatological Atlas).



Map 14.—HIGHLANDS AND MOUNTAINS. The mountain heart of Asia and the western-shore ranges of the Americas affect climate in totally different ways. The effect of the Eastern Australian Highlands upon Australian climates should be studied in detail.



Map 15.—ICE AND SNOW. Snow is here shown only where it affects land surfaces. The three mountains covered with permanent snow in Africa should be identified. Australia is the snowless continent—so far as permanent snow is concerned. The great heat of summer in Asia and North America greatly reduces the areas with permanent snow. The effect of the Gulf Stream and the Kuro-Siwo can be noticed in the distribution of seasonally ice-bound waters. The Gulf Stream drift prevents the formation of ice as far north as the Svalbard and Murmansk; the Kuro-Siwo does not reach so far north because of the Aleutian Islands and the Alaskan Peninsula. Ice-bound inland waters are clearly shown.

the temperatures recorded, but their corresponding sea level values (map 13). There are places, such as Mexico, Bolivia or Tibet, where temperature correction means the addition of many degrees.

When temperatures decrease a change in climatic conditions follows. During a climb of some thousand feet the same climatic changes may occur, which are recorded during a poleward journey of several hundred miles (fig. 5).

What height must one reach to notice a change of climate? It varies with latitude, season, moisture, and many other factors, but a rise of 3,000 feet will under any circumstances cause a noticeable change, and with a rise of 6,000 feet the change is complete. Map 14 shows these two important levels all over the World. They have a broken pattern; there are only three extensive areas over 6,000 feet, of which only Tibet is inhabited. The most important area over 3,000 feet includes nearly the whole southern part of Africa. Highland temperatures are lower than those of the surrounding country, and this results in the permanence of snow above certain levels over very small areas (map 15). Snow may fall or have fallen over much wider areas, as it appears from the same map: Australia is the only continent without permanent snow. Some of the great highlands of Asia fail to retain their snow cover permanently because of the rapid heating of the continent in summer.

Every highland and every mountain is a little climatic world of its own, with many peculiarities. Yearly temperature ranges are much narrower than on the plain. Although on a mountain it may

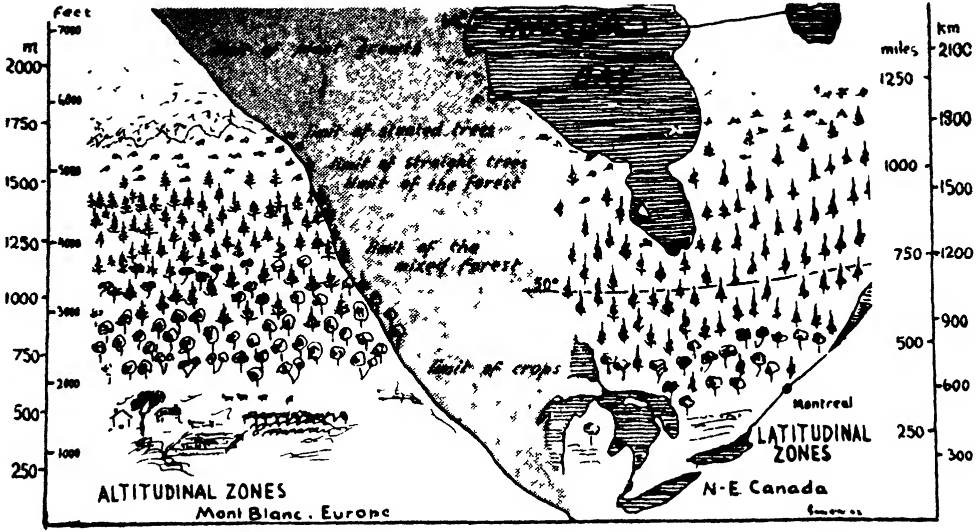


Fig. 5.—ALTITUDE AND LATITUDE. A comparison between the types of vegetation which occur up mountain slopes, and those which occur at various latitudes. Heights are shown to the left, poleward distances to the right. Very seldom do altitudinal and latitudinal zones correspond so closely; and even in the example given above, the limit of the mixed forest extends farther in altitude than in latitude.

be generally cold, its winter is not much colder than that of the plain, and its summer is much cooler. Mountain valleys often are colder than the mountains themselves, because cold air being heavier tends to sink to lower levels and "pile up" into the valleys; besides, mountain tops receive the first and last rays of the sun, while the valleys below are still—or already—in the shade. Aspect is also important: sunlit mountain slopes are warmer than slopes in the shade.

The rising of moisture-laden air against the slopes of a range or plateau causes rain or snow to fall (fig. 4). Consequently, the windward slope of the range or plateau is wetter than the leeward slope of the range or the interior of the plateau which come within the "rain shadow," as fig. 6 shows for the relatively low windward edge of the Western Plateau of Australia.[1] In the case of a high mountain range the difference would be much greater.

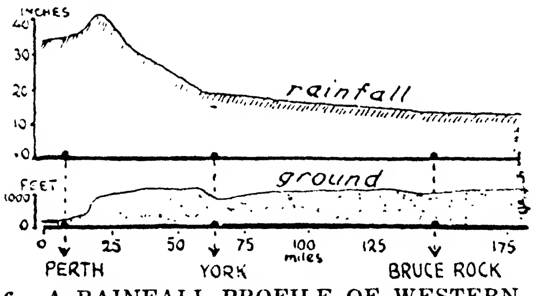


Fig. 6.—A RAINFALL PROFILE OF WESTERN AUSTRALIA. The very slight rise caused by the shoreline is sufficient to precipitate some rain. Although the interior of the Plateau is higher than its edge, very little rain falls since winds are no longer forced to rise.

1. Several more profiles showing the height of the ground, the average rainfall, and types of land utilisation, are shown in the author's "Atlas of Western Australian Agriculture."

Since there are different climates at different levels on a mountain, there are also different plant formations (fig. 5). It is difficult to set any rule; in general, the cooler the climate of the plain at the foot of the mountain, the fewer plants one meets while climbing, before reaching the snow line. Plant formations found at higher levels correspond to those found at sea level farther polewards.

Mankind is indebted to the highlands of South America for two most valuable plants, the potato and the tomato. Both grow wild on the Andes, and have been introduced into Regions at much lower levels and much higher latitudes. Many beautiful trees and shrubs now grown in temperate or even cold Regions come from heights of 10,000 feet or more in Inner China, as for instance, chrysanthemums, azaleas, rhododendrons, and magnolias. Coffee, which grows wild on the highlands of southern Abyssinia, still requires a highland climate in its adopted countries. Cinchona (quinine) trees growing wild on the northern Andes could hardly be grown in other Regions, until they were planted on the highlands of Java, where they could have equatorial sunshine and bracing air.

THE DEVELOPMENT

1. THE CONDITIONS OF PRODUCTION.[1]

As man must eat to remain alive, the first and most urgent need is food. We who expect our meals to be given us at regular intervals may not realise how urgent this need is. Men who live by hunting and have to obtain their food without anybody else's help, are always worried by the thought of the future, which may mean hunger and starvation, not only for themselves but for their families.

THE EVOLUTION OF FOOD PRODUCTION.

Stage	People	Mode of Production		
First	Australian aboriginals, Pygmies, etc.	Gathering, hunting		
Second	Mongols, Lapps, etc.	Hunting	nomadic animal raising	
Third	Masai, etc.	Hunting	nomadic animal raising	shifting agriculture
Fourth	Spaniards, Turks, Peruvians, etc.		Half-nomadic animal raising	settled agriculture
Fifth	English, Dutch, etc.		Stable animal raising	settled agriculture

The mode of food production and the climate of each country where these peoples live should be correlated.

1 Readers who wish to know more on this subject should get "The Growth of Civilisation," by Perry (Penguin Books), in which somewhat different views are discussed.

The need for food was satisfied first by gathering such fruits and vegetables as could be eaten raw, and by hunting or fishing. Only at a later stage did man discover how to light a fire and to cook his food.

There are even at present peoples who ignore food storage, or are unable to cook in an elaborate way. Australian aboriginals, living their traditional life, hunt animals, gather tubers, bulbs and berries, and collect grubs and eggs. Most foodstuffs are slightly roasted, and eaten quickly and wholly. Women make paper-bark baskets or light wooden bowls, in which food is sometimes carried for a while; but the climate makes it impossible to keep it very long. They have no vessel in which food could be boiled. Pygmies of the Congo and Bushmen of the Kalahari live in very much the same way.

In the course of his wanderings, primitive man sometimes reaches Regions where it is rather cold. He has therefore to face the need for warmth, which can be satisfied only by evolving some kind of dress. The skins of killed animals were the first coverings thought of, as they were ready at hand.

Australian aboriginals of the South-West wear roughly fashioned kangaroo skins during the cool season. Sealskin is still used as a clothing material by the Eskimos; other skins are used by some Amerindian[2] and Negro tribes.

Warmth is obtained also by fires, which of course are lit only during halts. If it is very windy, the fire is likely to be blown out, or to

2 Amerindians or Amerinds has been used by some authors to designate American Indians, since both "Americans" and "Indians" are misleading when used alone, and American Indians is awkward.

spread dangerously to the surrounding grass. Hence the need for shelter. This does not mean necessarily a roof, which is a much later achievement.

The wind-break shelter is still used at present by most Australian tribes, and by some tribes living in the forests of Borneo.

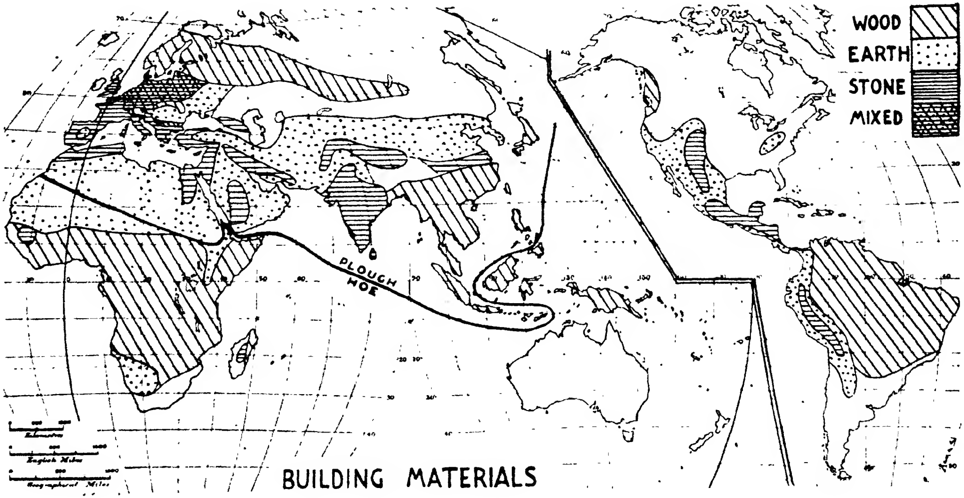
The need for a roof developed probably when man reached even colder Regions, so cold that even a fire was not enough to ensure rest during the night. A roof was also needed in hot Regions, where it rained heavily and frequently, and also for defence against animals roaming at night.

The material used to make the roof and the walls varied according to that which was available, and this is why there is such an astounding variety of dwellings in the World (map 16).

At the opposite ends of the two Americas, Eskimos in the extreme north and Amerindians in the extreme south make skin tents; but the Eskimos in winter replace them by ice huts. Most Negro tribes in Africa build huts, with thatched roofs, for which different kinds of leaves are used. The walls are made of mud on a latticed or woven support.

Even a roof and thin mud walls do not protect against dangerous animals and men. The need for security was so pressing at times, that all kinds of devices were adopted, such as clustering in villages, erecting wooden or stone walls around the hut or group of huts, building the hut high up on trees, or on stumps on dry ground or even over water on piles.

Any Negro village affords an example of protecting wooden barriers against both lions and



Map 16.—BUILDING MATERIALS. This map shows the chief building materials used in the various parts of the World before the spread of European civilisation; where Europeans have not settled in large numbers conditions have not changed. "Wood" means logs, planks or boards, generally used for the walls, and shingles or leaves for the roof. "Earth" means earth, mud or clay, either dried or baked (brick). "Stone" means either uncut or cut blocks of stone. This map should be compared with map 34 which shows the various types of forests, and with maps 5-8 which show the climatic Regions. The thick line shows the limit of the plough; outside the line the hoe is the main agricultural implement (adapted from Vidal de la Blache).

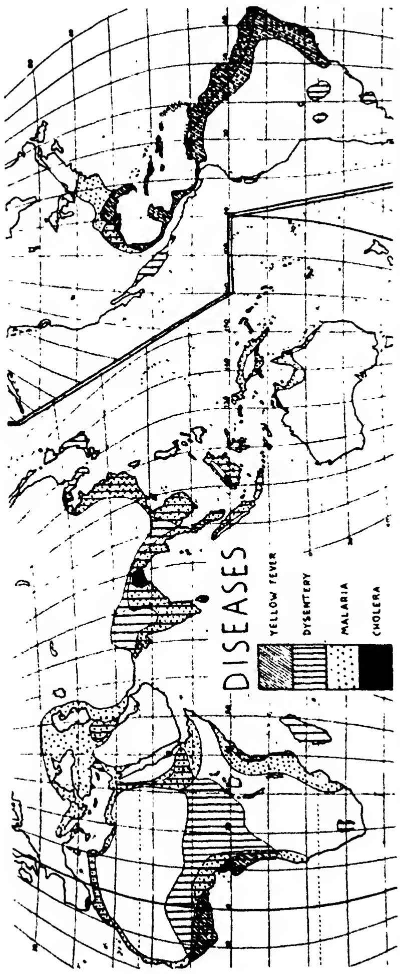
raiding enemy tribes. Papuans and Polynesians often build their huts on high piles, and use a ladder to reach their dwellings.

Unfortunately most peoples could not find protection against more dangerous, if less conspicuous enemies: diseases. There are many places where it is dangerous to live because of endemic diseases, that is, diseases which are always present there. Malaria is endemic in most hot countries, and is probably the most widespread disease. Cholera is at present restricted to the delta of the Ganges, where it is endemic: its outbursts, or epidemics, have often ravaged other Regions. Map 17 shows some endemic diseases of hot climates. The worst disease of cold climates is tuberculosis.[3]

A long as each family has to live by hunting or fishing and fruit gathering, there is little time left for social development. Even a fixed home is rather a hindrance, as sometimes the pursuit of game means walks of many miles, and hunters have to be away for several days.

It became therefore more and more necessary to leave behind those who could not join the hunting party, and their security became a new problem. Only if they joined forces could they defend themselves against animals and men. This was the beginning of human co-operation. There was already some form of co-operation between hunters but it did not go beyond what pack-hunting animals do. This new co-operation was more settled and regular, and enabled women and

3 Some diseases are associated with altitude; such is goitre, due to lack of iodine, a condition which is more likely to occur above 2,000 feet.
Other diseases are associated with soil conditions, as for instance the stock diseases caused by lack of copper in the soil (a condition found at places along the south-western and southern coast in Australia).



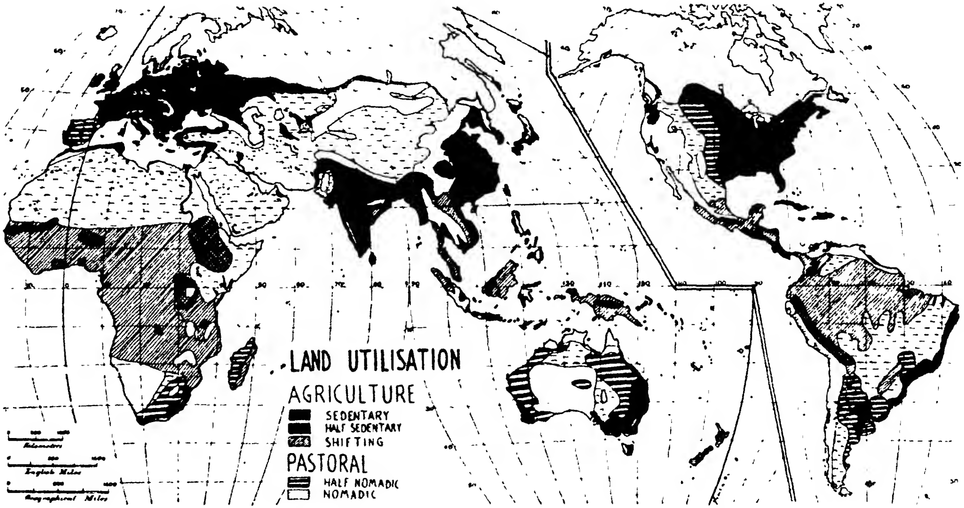
Map 17.—DISEASES. The distribution of some typical diseases (after Brettle) is shown and should be correlated with the map showing the height of the land.

old people to carry on their work and watch the children in relative security.

One of the early great developments was concerned with the growing of edible plants. Men had to go out hunting, fishing or gathering, and had no time to notice what happens to seeds dropped on the soil. Women lived in villages and took care of children and food. Most likely a woman noticed that some grains and some tuber cuttings thrown away had begun to sprout and grow. This could happen only where there was enough rain or a flood had taken place; its importance could be realised only where somebody lived on the place long enough to notice it.

Hunting peoples who never discovered agriculture have already been mentioned. It is difficult to find where agriculture began, but it is not unlikely to have started in Lower Egypt, where the Nile floods the country at regular intervals and fertilises it with silt. In the great river valleys of the temperate climates—except in North America—settled (sedentary) agriculture began certainly very early and has continued ever since. In many other countries it is still spreading until it reaches the dry margins, where natural water is insufficient for crop production. In very arid or very rainy countries, people still pursue a kind of nomadic agriculture, tilling the soil, growing a crop or two and then moving to another ground; in forest Regions this implies a considerable amount of work (map 18).

While meat, fish and most fruit do not keep long, and have to be eaten as soon as possible, grains can be stored for a long time. Hence the need for containers, which ensure safe storage and also easy transport.



Map 18.—LAND UTILISATION. The large areas where shifting agriculture is practised should be compared with the equatorial forests on map 34. The areas of partially shifting agriculture should be compared with the mountain ranges. Most of the lands where sedentary (settled) agriculture prevails appear as blanks on map 33. The tiny dots showing oases are of great human interest. The areas where pastoral activities are carried on should be compared with the dry areas (shifting agriculture according to Whittlesey).

A craving for beauty seems to have developed very early in human beings. It is of course difficult to know what beauty actually means, but to simple men it means above all decoration. The most primitive civilisations have developed some artistic patterns which are used over and again on all implements and clothes and dwellings, with variations and additions. Thus art has evolved, and ornaments vary in shape, size, colour and material. Decoration of pottery and clothes has become a craft with its masters and its traditional secrets.[4]

People realised very early that they could exchange food and other articles to their mutual advantage. Thus trade began. At first there were exchanges only between members of nearby groups. Later on several villages, even from far away, sent people to barter things. This made it advisable to have regular tracks along which to travel with comparative safety. Means of communication were already in existence, because successful hunters had learnt how to signal home by smoke columns, and villages often kept special drums to be used to communicate with other villages far away. Relays of several such devices worked—and still work—very well and with amazing results, so that news may travel hundreds of miles within a few hours.

Soon it was found that some goods were in universal demand. Salt was the most important one, followed by tea in Inner Asia. It is relatively easy to express the value of anything in terms of salt cakes or tea bricks. Salt and tea are still used as a currency. Salt is especially appre-

4 Read "Primitive Art," by Adam (Penguin Books).

ciated in Regions far from the sea, such as the Amazon Basin and the Congo. Cowrie shells, as well as salt and tobacco sticks, are used in New Guinea. Especially in Africa, goats and cattle often express the value of things and persons. Metal coinage was first used near the Mediterranean, where copper was available. It soon spread to other lands, and other metals were used, mainly gold and silver. At present paper notes are used by most countries—together with silver, nickel and copper coins.[5]

The need for exact and detailed news and for a record of exchange transactions led to the use of some marks cut on pieces of wood, bone or other material. Such signs were already used as ornaments on clothes and weapons, on which they did not mean more than they actually showed, a bird, a flower, a man. When they came to be used to record news or business, more elaborated combinations became necessary, until writing came into being.

Australian aboriginals have not evolved any currency system, and can only barter; they have, however, discovered how to inscribe complicated message sticks, which most likely refer to news of ritual gatherings. Their smoke signals are said to have reached a remarkable precision and detail. No actual writing has been evolved in the whole of Oceania, and even the Maori, who reached the highest degree of civilisation in the South Seas, retold their wanderings only by word of mouth. They had, however, devised a skilful system to show the course of navigation by a

5 In these coins pure metals are never used because they are too soft; alloys of varying composition have been found to be much more durable.

lattice of wickers or twigs, a sort of simplified chart.

Once men were able to communicate with each other both by speech and at a distance, they began to exchange ideas, too, and to learn from each other.

II. INDUSTRIAL ACTIVITIES.

Most human activities are directed towards the production of goods or services, and it is therefore necessary to distinguish between the various types of production. Production of goods which are obtained directly from nature is called primary. Primary products are often consumed as such, but many of them require some processing. Production of processed goods is called secondary. In this case primary goods are called raw materials, and secondary products may be called manufactured. In modern times, tertiary production has become important. It includes any kind of services, such as transport, medical attention, education, entertainment.

Several primary industries take from nature, without replacing what they take. Typical examples are hunting, fishing, gathering, forestry and mining. These may be termed destructive industries. For instance, when we speak of wonderful mining achievements, we must remember that what has been wrested from the Earth will never form again. The same is true of the other primary industries listed above, and this is why fur-farming and afforestation are signs of a great progress, a progress in the way of thinking and living rather than in the way of exploiting the Earth.

Agriculture, pastoral activities, the above-mentioned branches of hunting and forestry, are reproductive industries. The Earth is partly exploited, much plant food is taken for ever, but most of the products are obtained by reproduction.

PRIMARY PRODUCTION.

The simplest primary industries are gathering, hunting and fishing.

Gathering of wild fruits and edible roots still goes on among primitive tribes. Where man can grow almost any useful plant, gathering is now restricted to certain mushrooms, bilberries, huckleberries and other berries and plants of medical value, such as henbane, stramonium, and many others which are not usually grown as a cultivated crop.

Hunting may be carried on to obtain meat, and this is still the main occupation of peoples such as the Eskimos, the Indians of the Amazon, some Negro tribes, and nomadic Australian aboriginals. Modern man has found easier ways of obtaining meat, and hunting for meat in the western world is limited to game hunting. Hunting for hides is more important and affords a living to many enterprising men. The most valuable branch is hunting for furs, but man has found a better alternative, fur farming, that is, rearing fur animals on farms. Sealing and whaling are other forms of hunting.

Fishing provides mainly fish for food, but skins and oils are sometimes obtained as well. The establishment of oyster beds deserves special mention. Man has also introduced foreign species of fish into many lakes and rivers, for instance, trout in New Zealand and in the cooler Australian rivers.

Forestry is not very important in simple communities, which, however, draw many of their supplies from trees. Our type of civilisation requires enormous quantities of timber for build-

ing, pulping and other purposes. Forestry has been for too many years a highly competitive industry and consequently there has been ruthless destruction of useful trees; it has now become a carefully managed public concern, in which private enterprise is closely supervised. Agriculture has destroyed the forest over wide areas of Eurasia and North America, but efforts are now being made to restore what is possible. Man can do very much in this direction, by replanting young trees and carrying out what is known as reforestation. Afforestation is the planting of trees on lands where there were no forests under natural conditions.

The methods of hunting, fishing and timber-cutting have been improved by modern science. but fundamentally they are the same as they have ever been.

The most amazing progress in primary industries has been made in agriculture. There are still tribes ignorant of agriculture, and others whose only implement is a hoe and who after one or two years abandon their fields and shift to new areas (maps 16 and 18).

It is interesting to know in which Regions shifting agriculture is still practised at present, because it implies a regular clearing of natural vegetation to make room for crops, and a regular return to forest as soon as crops are harvested. In this way, the soil is not exhausted, and the forest is not permanently destroyed (map 18), but this method of agriculture can only support a few people over several square miles of land. Where the ground is very rugged, shifting is not easy, and cultivation is resumed on the abandoned

ground after two or three years (map 18). The denser the population, the more difficult shifting becomes, and sedentary or settled agriculture becomes then a necessity with its natural consequence: the destruction of forests. In the vast majority of agricultural communities the implements have been increased in size, variety and efficiency—examples are the modern plough and the harvester—and the tractive power which was at first supplied by human muscles and later on by animals is now obtained from engines driven by petrol or other fuels.

It is impossible to list here all that agriculture provides: tubers, bulbs, rhizomes, rootstocks stems, leaves, flowers, fruits, seeds of many plants are produced for human food; even some barks and flower buds are produced as spices. With the improvement of pastoral activities, fodder has also to be grown, and now several important crops are devoted to this purpose. The expanding textile industries require more and more fibres, and agriculture has to provide several kinds of them.

Several plants which were previously forest products, are now grown in plantations, and not only has the quality greatly improved, but the yield has become much more reliable. Such is the general trend of most of our present agricultural crops, which were once wild plants. Sometimes breeding has produced changes, called mutations, which, together with careful selection, have created altogether new varieties from a common ancestry; for instance there are now hundreds of wheat varieties. In some cases, there may be cultivated plants which have no wild

counterpart, as for instance the nectarine and the loganberry.

Pastoral activities have developed independently from agriculture in all dry Regions, where it is necessary to move the herd frequently in quest of new pastures (map 18). In wet Regions, where agriculture is easy, animal production is less important, and does not reach a great development until modern times. The first use of domestic animals was most likely for meat production; the hides were used for several purposes, and later, when weaving came into being, the hair was spun and woven.

It is not likely that milk was used at an early stage, and even at present fresh milk does not keep in warm or hot lands, and must be transformed into cheese. Few agricultural people use butter very much, since they have plenty of animal fat and vegetable oils, and butter becomes easily rancid. However, many peoples in Africa and Asia use rancid butter and like it.

It is not known which animal was domesticated first, but it is likely to have been either the goat or the sheep, both easy to handle because of their small size, the former rich in milk, the latter giving wool. Cattle, bulkier and stronger, could be tamed only by people living in villages as it is easier to tend the animals and herd them together near the villages than far afield when horses are not available. In the vicinity of villages there is to be found sedentary agriculture, to which the strength of oxen and buffaloes for dragging loads becomes a valuable aid.

No indigenous American animal has been tamed to work in the fields; this placed a much

heavier burden on early American cultivators than on their Eurasian contemporaries.

The taming of animals for carrying loads has gone on independently. Donkeys have been used around the Mediterranean for thousands of years; horses were first used in Central Asia. In other countries, either man has to carry his burden, as in New Guinea and parts of Africa and the Americas, or local animals have been partly tamed to carry burdens, such as camels in Central Asia and North Africa, ilamas (*lyamas*) in South America, yaks in Tibet, reindeer in the Arctic, elephants in India. Some animals are used only for draught; dogs are used for this purpose in Arctic lands. Some of the pack or draught female animals may yield milk for human use.

Man has learned to keep birds for their meat, their eggs, their plumage or their song. Insects are too tiny to be noticed by primitive man, unless they are a nuisance, though the Australian aboriginals gather grubs, honey ants, and honey from wild bees. The Chinese, with their love for nature and detail, have discovered the beautiful and strong thread produced by the silkworm, and still use it. Bees were first kept in Mediterranean lands, in northern Europe somewhat later.

Primitive man uses some mineral products; Papuan and Australian natives make tools and weapons out of stone, and still exploit deposits of pigments (coloured iron compounds), but this activity could hardly be called mining or quarrying.

The first metal to be used was possibly copper, which is soft and easily worked, and was found in the island of Cyprus, near the oldest Mediterranean centres of civilisation. When later on the

greater strength of bronze was discovered, expeditions went to the Scilly Islands and to Cornwall to obtain tin which was alloyed with copper to make bronze. In the meantime, the beauty and rarity of gold and gems had struck the eyes and mind of many peoples, and a keen demand for them had arisen.

Man probably began quarrying in Egypt and brick-making in Iraq (*Irakh*) long before metals other than copper, tin and gold became known.[1] These industries were also known in China from early times; clay for the making of pottery and tiles was a very important quarry product there.

These industries either spread from these early centres, or were independently rediscovered in later times. At present they are almost universal, at least among sedentary peoples.

Iron was discovered much later, almost at the beginning of historical times, by wandering warlike tribes, who used their powerful iron weapons against the highly developed, but weaker, peoples using bronze or copper. We do not know where it was first discovered how iron could be extracted from iron ore, possibly somewhere in the great Eurasian plains.

Today there is hardly a mineral or rock for which man cannot find some use. The terms mining and quarrying have been extended to include the production of any mineral, be it gaseous (such as natural gas), fluid (such as petroleum and mercury), or solid (such as any metal except mercury). Means of extraction have of course developed according to the new range and variety of minerals of economic interest.

1 What remains of these ancient civilizations is described in "Digging up the Past," and "Ur of the Chaldees," by Woolley (Penguin Books).

TRANSPORT AND COMMUNICATION.

Transport developed as soon as it became desirable to carry goods to meeting places for exchange. Even at present in Equatorial Africa people hire caravans of porters, who only a few years ago would have been slaves. In other countries pack animals are advisable where the ground is very rugged. For extremely smooth surfaces, such as snow and ice, sledges have been evolved. Scandinavian skis and Canadian snow-shoes are used by travellers on snow-covered ground. The greatest invention so far as transport is concerned has been the wheel, without which transport might have remained absolutely primitive. The wheel was not known in America, parts of Africa, Australia and New Guinea.

The hull is older than the wheel; water transport is mentioned in the earliest documents of mankind, long before carts and carriages. The simplest form of water transport is by drifting logs. An assemblage of logs form a raft. These primitive means of transport can be steered only by poles; this is enough to enable man to navigate not only rivers, where logs and rafts travel with the current, but also lakes. It was impossible to go out to sea before the invention of the paddle, which preceded or came together with the oar used in so many countries. Eskimos are very skilled in using paddles; European and Asiatic boatsmen prefer oars, with which they row either sitting or standing. On many Chinese rivers and on the Tigris and Euphrates as well, poles are used.

When logs were first hollowed out, the first boat came into existence; it is not impossible that

the first boat or canoe was actually made out of bark in countries where suitable trees existed. Even now, some Australian tribes of the North use bark rafts, whereas others make bark canoes, and some dug-out canoes.

Boat or canoe, paddle or oar have spread almost everywhere, and so has a much later invention, the sail, which has enabled man to use one of the great sources of power, the wind. The rudder soon became necessary, and its use has spread widely. Another great invention, the outrigger, has not spread even over the whole Pacific, and yet thanks to it Polynesian tribes have colonised many islands and performed wonderful feats of high-sea navigation. The outrigger has even developed into a double-hull canoe, which can live through the stormiest seas.[2]

Nothing except size and materials used changed until other sources of power were found and the first paddle-wheel ship was built. With slight alterations such a type of ship is still used on the Mississippi. When better steam-powered engines were made it became possible to use the screw for water propulsion.

Progress in physics enabled man to devise something that could float into the air, and the first balloon—inflated with hot air—was invented, in relatively recent times. Balloons of various types are still used for barrage or for stratospheric exploration. After the application of the screw to water transport the airscrew was invented and

2 A modern reconstruction of this craft is fully described in "The Voyage of the Kamila," by De Bisschop. Bernatzik in his "Sudsee" gives photographs of the double-hull orou still used by the Melanesians of Mailu, a small island south-east of New Guinea. Simple or double outriggers are used as far west as Madagascar.

first applied to airships, and then to the newly invented airplane. Airships are little used now, but airplanes have been greatly improved, and are now used for flight at low or high levels, for alighting on land, snow or ice, or water, being respectively fitted with wheels, ski and floats. Flying boats are built with a proper hull.

The most recent invention applied to air transport is the jet engine, which makes it possible to reach greater speeds and greater heights than with any propeller. Fast rail transport may also be greatly improved by this invention.

Means of communication have progressed very slowly, and until recent times nothing was found better than relays of ancient devices, such as smoke signals or messengers. Mirror (or light) flashes and carrier pigeons are devices still being used at present for special purposes. Now electricity has radically changed communications through the invention of telegraphs, telephones and wireless.

SECONDARY PRODUCTION.

Secondary production utilises as its raw materials primary products which have to be transformed into secondary products by some processing. Sometimes these primary raw materials have no value as such and acquire a value only after having been transformed into secondary products.

It is hard to know which secondary industry developed first: most likely it was some very primitive sort of tanning, to make hides durable and flexible. This is the only secondary industry which was known to some South-Western Austra-

lian tribes. Some Northern Amerindians knew little more, that is, they could cut and sew skins to make tents and garments. Spinning and weaving followed tanning. Pottery became an important industry in villages, where storage of agricultural products was a problem; it is likely to have started from basket-making. Baskets still are smeared with clay to make them watertight. The clay may be dried in the sunshine, or baked. Both methods are used in parts of Africa. Other peoples have discovered that the basket is no longer necessary, and bake pottery from properly shaped clay. These industries with the addition of some very simple carpentry are all that is known by some human groups such as the Amerindians of Peru.

The use of metals made it possible to make many useful objects, such as pins, needles, hooks, blades, axes, spades. This gave rise to a whole series of industries, which became more and more specialised. Once transport had made exchange easy, trade in raw materials became at least as important as trade in processed goods. This led to modern industry, in which specialisation is based upon an easy and frequent exchange of raw materials and finished goods.

The improvement of transport and communications and the harnessing of power produced a great range of specialised industries. There are alimentary industries, concerned with food and drink supplies; textile and leather industries, concerned mainly with clothing and allied needs; building and carpentry; mechanical industries, which have acquired a great importance and cover the widest range of activities, from

needle-cutting to shipbuilding; chemical industries, which are now of basic importance to human life.

While primary industries are seldom interrelated, interrelation is perhaps the main feature of secondary industries. The automobile industry affords a good example; it draws petrol from the refining industry which in its turn draws petroleum from a branch of mining (primary) ; it uses steel alloys produced by the most specialised branches of metallurgical industries, which obtained their ores from branches of mining (primary) ; it uses leather got from the tanning industry, which treats hides obtained from pastoral or hunting activities (primary), with tannin which is produced by the chemical industry from either vegetable or mineral sources (primary) ; it requires paints and varnishes made by chemical industries which obtained their raw materials from agriculture, forestry and mining (all primary) and uses brushes produced by a special secondary industry which uses animal, vegetable or even chemically-made bristles; it uses rubber tyres prepared by a special chemico-mechanical industry which requires enormous quantities of raw rubber, which may have been either gathered from wild trees (primary) or obtained from plantations (also primary) or else produced chemically (secondary) from minerals (primary).

TERTIARY PRODUCTION.

Tertiary production requires more skill and less natural goods than secondary production. Some tertiary production existed, however, long before man even thought of secondary industrial activity.

Primitive tertiary industries are of course very simple. The fear of evil spirits led man to look for somebody able to turn these spirits away, or even to change them into good ones. Thus sorcery came into being, and was probably the first tertiary industry. And as primitive man conceives a very elementary idea of religion based only on good and evil forces, sorcery has become deeply involved with religion. Natural happenings which cannot be easily and promptly explained are attributed to spirits. Few men ever know—in simple communities—why they are sick, and they may throw the blame upon evil spirits. The man who deals with evil spirits is the tribal sorcerer, and they ask him to rid them of their illness. Medicine thus became perhaps the second tertiary industry. Amongst most Australian tribes, several Negro groups, and possibly still some Eskimos, sorcery, medicine and religion are closely related.

Decorative art has also appeared very early in human communities, being often associated with the expression of religious feelings; later on, man began to decorate weapons and implements, clothes and dwellings, for himself at first, for others later.[3]

It is impossible to mention all other tertiary industries. Art and entertainment have taken very many aspects in modern times; they, too, began as religious activities, such as the decoration of sacred places or instruments, the representation of the coveted animal in order to make its capture easy, ritual dances and concerts held on certain occasions. Every people has some form of decorative art, from the simplest dotted pat-

3 Adam, "Primitive Art," Penguin Books.

tern used by some Australian tribes[4] to the terrifying convolutions shown on some Maya temples. Pictorial art, concerned with the representation of definite objects or beings, does not exist everywhere; some Australian tribes are not able to represent anything by drawing, while others execute some remarkable rock paintings.

Sculpture is practised almost everywhere. Some artistic products brought from far-away countries or found among old ruins show the existence of specialised artists among relatively simple communities. It is likely that such arts as mentioned above developed very long ago into industries, with specialised craftsmen. Singing, playing, and dancing which had been practised since early times did not become actual industries until much later.

The most numerous tertiary workers are servants: they came into being when agriculture began, because before agriculture was known the hunter could not have utilised them; besides, he did not need labour. The first servants may have been slaves; in this case, they were actually a primary source of power, like cattle. With the decline of slavery, hired labour assumed an ever-increasing importance, until today it is one of the bases of modern industry and in many countries of agriculture as well.

In countries where transport and storage are well developed, distribution of goods, commonly known as trade, is very important. It is a typical tertiary industry; it may be based on either retail or wholesale organisation, and shows many

4 McCarthy, "Australian Aboriginal Decorative Art," Australian Museum, 2/6.

aspects, from the pedlar to the big chain store, from the man who travels Africa on foot to buy elephant tusks to the man who in New York sells ten thousands trucks by a single telephone call.

SECURITY AND CO-OPERATION.

In troubled times the need for security became so pressing that men who were unable to protect themselves against enemies and robbers sought the protection of some powerful lord, and paid for this type of service. This is what is known under the name of tribute, and it lasted until the present day in Inner China and parts of Africa.

In many communities the protection of the lord over the cultivator has become more and more financial, and in most countries with an age-old agriculture, the cultivator who is a peasant, often very poor, living on the land, works mainly to repay the banker or the moneylender who supported him in bad agricultural years. The peasant owns the land, but is not free to sell it lest he endanger the rights of his financial supporters. This is the situation over most of India. Something similar has developed in younger countries, with the difference that there there are farmers and not peasants. The peasant grows various crops to feed himself and sells the surplus, while the farmer depends on the sale of his one or two crops in order to carry on. Over most of Europe the peasant seldom owns his land. He works for a landlord who lives often in town, and contributes land, machinery and cattle, and half the seed. The peasant provides labour, tools and the other half of the seed. The crop is equally shared. This system is called metayage. It involves a

sharing of risks by landlord and peasant. In other cases the peasant has to pay a fixed rent to the landlord, be his year good or bad. This may lead to a permanent indebtedness, as in parts of China, where sometimes the peasant must borrow food and money in order to carry on during bad years; and in good years, through plenty, prices fall, so that the plentiful crop is sold at such a low price, that often he cannot repay the debts accumulated in the bad years.[5]

The dangers of permanent indebtedness prompted cultivators of many countries to join forces in order to share their own risks without having to pay for outside help. This is called co-operative organisation. The fine achievements of dairy-farming in Denmark are mainly due to this type of organisation. Much is done in Switzerland, too. In British countries, consumers have founded co-operative societies in order to deal with distribution of goods, a tertiary industry, in which less collective effort and discipline are required than in producers' co-operatives. Australian friendly societies offer another fine example of tertiary co-operation for the provision of medical services.

The most complete scheme operates in the Soviet Union, where the whole life of the country is organised on a co-operative basis, thus making it possible to introduce modern methods where feudal systems prevailed only a few years before.

5 W. M. MacMillan, "Warning from the West Indies," Penguin Books, gives an interesting account of similar developments in the small communities of the Antilles. A good description of agricultural life in China may be found in "The House of Exile," by Nora Waln (Penguin Books).

III. GRAINS.

So many types of goods are produced in the World, that it is difficult to study them unless some definite classification is followed. The following arrangement is adopted throughout the book:—

Products			Chapter	
Vegetable	Agricultural	Edible	III	Grains
			IV	Vegetables and fruit
			V	Beverages
			VI	Sugar, spices and drugs
			VII	Vegetable fats and oils
		Non-edible	VII	Vegetable fats and oils
			VIII	Vegetable fibres
			X	Other vegetable products
	Forest		IX	Forest products
	Other		X	Other vegetable products
Animal	Pastoral	Edible	XI	Meat
			XII	Other animal food-stuffs
		Non-edible	XIII	Animal fibres and other products
	Fishing and whaling .		XIV	Products of the sea
	Other . . .		XIII	Animal fibres and other products
Mineral			XV	Iron and steel
			XVI	Other industrial metals
			XVII	Non-metallic minerals and rocks

It is surprising what a small area is cultivated in the whole World; if all areas under all crops except fodders were distributed over Australia, without any overlapping, they would not cover the whole continent (fig. 7) ; two-thirds of it only would be covered by grain crops.

Although the vital role which grains play in human life is well known, there are some frequent misconceptions as to the relative importance of such grains so far as quantity is concerned (fig. 8). The great Regions of the World not only produce different quantities of grains, but the type of grain they produce varies very greatly (fig. 9).

A LIST OF GRAIN CROPS.

Main use and crop	Climatic requirements	
	Temperature	Rainfall
A. Human food		
wheat	warm, cool, cold	low, moderate, heavy
rice	warm, hot	heavy
barley	warm, cool, cold	low, moderate
rye	cool, cold	moderate
buckwheat	cool, cold	moderate, heavy
B. Animal food:		
maize	warm, hot	heavy
millets	warm, hot	low, moderate
oats	cool, cold	moderate, heavy

Wheat has been known since early times, and several species have been found together with fossil human remains.[1] With barley, wheat was

[1] A very short account of studies on the origin of wheat is given in the essay, "History in the Light of Genetics," by Haldane. Published in "The Inequality of Man" (Penguin Books).

the basis of the ancient Mediterranean civilisations. Such age-long cultivation has led to the breeding of many varieties with special features, but the two main groups, which are two quite different species, are hard wheat (macaroni wheat)[2] and bread wheat.[3] The former has a much harder grain and more gluten, a substance which is of great food value. The latter gives a better bread, although some hard wheat is also used for bread-making. Hard wheat is grown mainly around the Mediterranean, in South-Eastern Europe, India, and the drier areas of North America; bread wheat is grown almost everywhere else, in much greater quantities. Some harder types of bread wheat are said to be "hard"; they are not the true hard wheat.

The main use of wheat is for bread-making. The grain is crushed at mills—driven by water-wheels where water is available, by animals in dry countries, by the wind, and in modern plants by steam or electric engines—and made into flour. Most flour is worked into bread. Wheat is exported sometimes in sacks and more often in bulk, flour is exported in sacks. Grain is stored rather than flour, either in the open air, or in granaries, or in special tower-like windowless buildings called silos; the great enemies of stored wheat are weevils,[4] rats[5] and mice.[6]

Wheat can be grown both in Temperate and in Cold Regions. It is limited polewards by the coniferous forests, where the growing season is too short. Towards the dry areas, its limit is set by

2 *Triticum durum.*
3 *Triticum vulgare.*
4 *Calandra granaria* (granary weevil) and *C. oryzae* (rice weevil).
5 *Rattus norvegicus* (sewer rat) and *R. rattus* (ship rat).
6 *Mus musculus.*

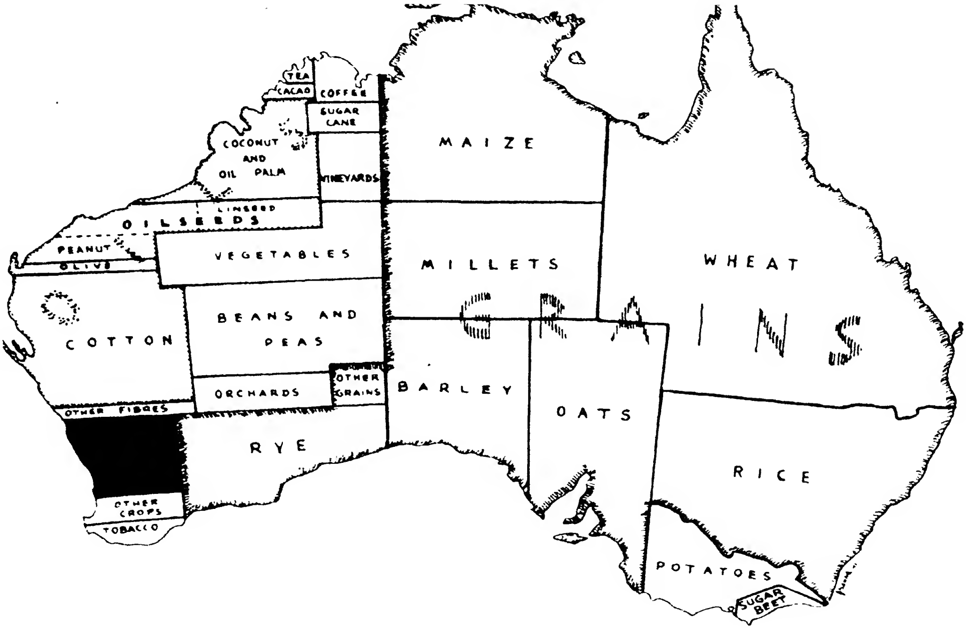


Fig. 7.—WORLD CROPPED AREA. All the areas under crops (excluding pastures) have been plotted on a map of Australia. All the wheat fields of the World cover exactly the area of Queensland. All the rice fields would barely cover New South Wales. This is far from implying that wheat could grow anywhere in Queensland or rice anywhere in New South Wales—the above drawing is a diagram, not a map. The black area shows what would remain empty after all the cropped areas of the World have been plotted on the diagram (areas after League of Nations' Yearbook, Imperial Economic Committee's Publications, and Huntington, Williams and van Valkenburg).

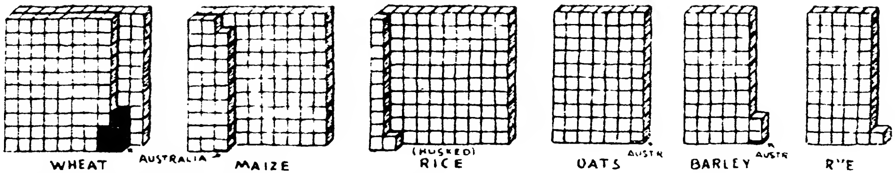


Fig. 8.—PRODUCTION OF GRAINS. One cube represents 1,000.000 metr. tons. Australian production is shown black; too little rice and rye are produced in Australia to be shown in the diagram. Maize is now the second grain crop of the World. There is no information concerning millets.

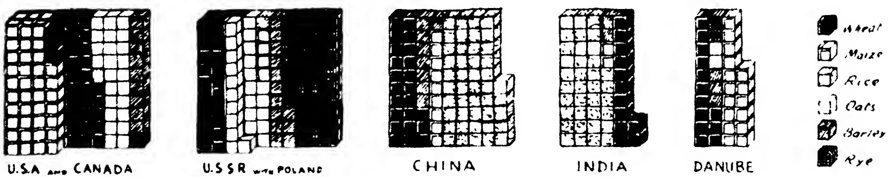


Fig. 9.—THE GREAT GRAIN PRODUCERS. One cube represents 1,000,000 metr. tons. "Danube" includes Hungary, Roumania, Yugoslavia and Bulgaria.

insufficient rainfall, which varies according to the climatic type; winter rainfall is more useful to the plant than summer rainfall, which evaporates too soon. In the Cool West-coast Regions it may rain sometimes too much in the early summer for wheat, which is therefore grown in the drier spots. Where rainfall is scanty, wheat yield varies according to the rain, and dry years may prove disastrous. In semi-dry countries irrigation is extremely valuable, since it may check droughts, and also extend wheat cultivation into drier areas. In hot countries wheat cannot be grown because the temperature is too high, but it may still be grown in them where highlands create more favourable local climates, or under special conditions of rainfall such as prevail in parts of India.

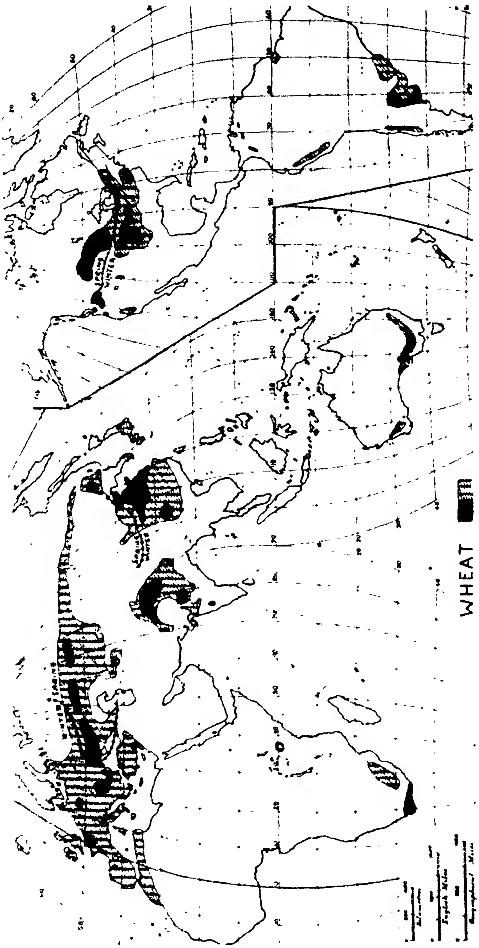
Although wheat can be grown on almost any type of soil, the best results are obtained on the black earths, because of their richness in certain constituents and because the flatness of the ground enables large-scale operations. On the other hand, because wheat is an exhausting crop, the chemical elements which it takes from the soil must be restored by manuring if they are scarce in the soil under natural conditions. These operations are rather costly and it pays to do them thoroughly only where a dense population provides an easy and eager market. The yield per acre is over three times as great in the densely populated European countries, as in the thinly inhabited plains of Canada and Australia. Asiatic densely populated countries such as China and India have low yields mainly because seed selection is seldom practised, or is rather unsatisfactory when done.

Selection of suitable wheat varieties and their continuous improvements have made possible the extension of wheat-growing to Grassland Regions where special farming practices—"dry farming"—have to be used. Quickly-maturing wheat varieties have been evolved, which can grow within the very short northern spring of Canada and the Soviet Union, and ripen during the warm summer, when there is sunlight for 16 to 18 hours a day.[7]

Any good atlas shows where the main population clusters occur. Wheat is grown in temperate and cold countries to supply these clusters, while in hot countries it is often superseded by other grains. Canada, Argentine and Australia are sparsely populated and can afford to produce for export to other more closely populated or climatically less suited countries. One of such countries is Great Britain, which is in part climatically unsuited—too wet in summer in the west and north—and which for economic reasons gave up wheat-growing over a century ago for other apparently better paying industries. On the other hand, some countries such as France, Italy and New Zealand which normally can only produce part of their wheat requirements, have supported wheat-growing for political or economic reasons. Countries with a very large population, such as India, the Soviet Union, the United States, are alternately importers or exporters according to the vagaries of the season.

Because of the different times in which seasons reach different countries, there is always some

7 A very brief account of Soviet scientific work on quick-maturing wheat is given under the heading "A Great Soviet Biologist," in "Science and Everyday Life," by Haldane (Penguin Books).



Map 19.—WHEAT. Major areas are shown black; their climate should be studied in detail. The boundary between hard wheat and bread wheat cannot be shown because the two types are grown together in many European countries. In North America hard wheat is grown in the drier areas of the United States and Canada.

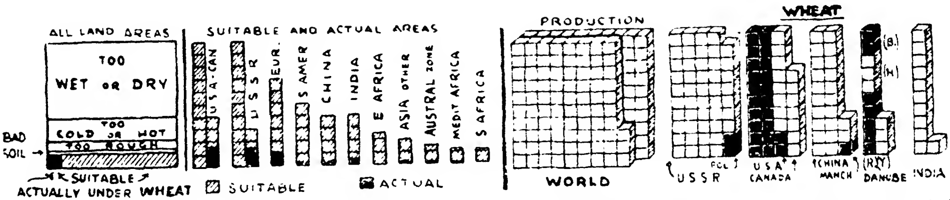


Fig. 10.—WHEAT AND NATURAL CONTROLS—PRODUCTION OF WHEAT. (a) shows what percentage of all land areas is suitable for wheat cultivation, and what is actually under wheat. (b) Shows the area suitable for wheat cultivation in each great zone, and the respective area which is actually under wheat (estimates after Baker; one square represents 1,000 sq. miles). Areas which are suitable for wheat are often devoted to other equally important crops. (c) Shows the World production of wheat (one cube is 1,000 000 metr. tons); Pol. stands for Poland, Manch. for Manchuria, B. for Bulgaria, H. for Hungary, R. for Roumania, Y. for Yugoslavia.

wheat being harvested somewhere in the World. One may list countries according to their harvest-time which depends mainly on temperature or on rainfall. In monsoonal lands harvest-time depends mainly on rainfall: in India wheat is sown after the rains and harvested in February. Other lands where the influence of temperature is great, harvest in summer, from Argentine and Australia which harvest in December and January, to the Ukraine and the United States which harvest in June and July. Sowing-time varies, too, according to winter cold. In mildly cold countries the seed may be sown in autumn, when it begins to grow, until the first snow checks its growth and protects it from cold. This is called winter wheat. In cold and very cold countries the seed would die in winter, so it is sown after thawing time; this is called spring wheat. The harvest-time for both winter and spring wheat is about the same, falling about mid-summer or later. In temperate countries wheat is sown in autumn; this should be called winter-grown wheat, but usually it is plainly called "winter" wheat.

Wheat is grown over a much greater area than any other crop, but the total quantity produced does not greatly exceed that of maize or rice, which yield much more per acre (fig. 8). In every continent there are wheat districts or "belts."

Wheat consumption varies mainly according to the amount of bread consumed. Thus the largest consumption per head is found in France, Italy and Roumania, where meat consumption is low; whilst the great meat eaters, North America, Great Britain and Germany consume half as much wheat per head (fig. 47).

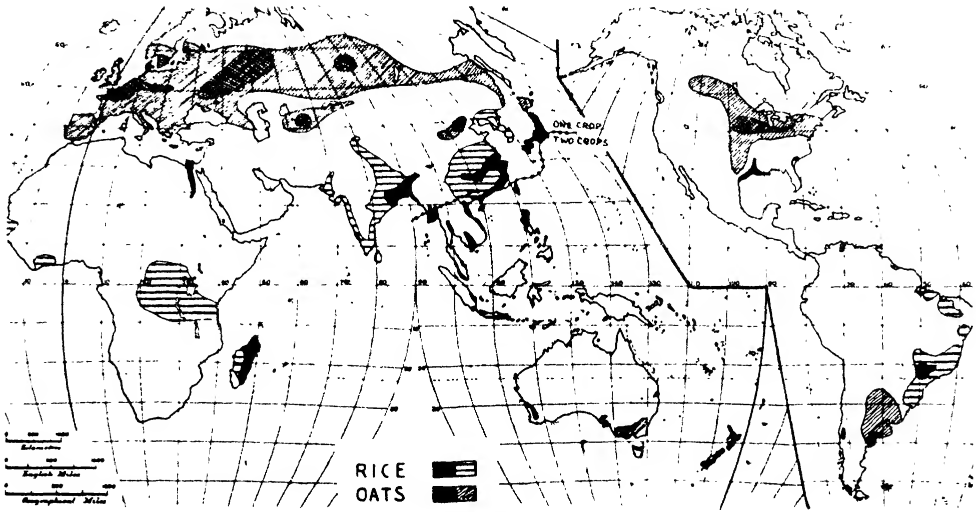
Although it is principally used for human food, wheat, where it is cheap enough, may be used as feed for domestic animals. It is a raw material for the making of many foodstuffs on the one hand, and alcohol on the other. The main article of food obtained from wheat is flour, which is used to make bread, if obtained from bread wheat, and bread and macaroni as well if obtained from hard wheat. Many other foods are made from flour. Wheat flakes are obtained by opening up wheat grains by means of rollers, and toasting them.

Straw is used as litter for animals, for packing, and as a raw material to make wrapping paper. The whole wheat plant, when still green, may be either cut down and cured for hay, or fed to animals as green feed. Bran and pollard, very important animal feed, are by-products of wheat milling; they are obtained from the outer shell or skin of the wheat grain.

Rice[8] grown where the greatest population clusters are found is the staple food of about one-quarter of mankind.

Rice is closely related to wheat, and like wheat was known since the beginning of agriculture; hard wheats supported Mediterranean cultivations, and rice supported China. This age-long cultivation has resulted in the development of many varieties of rice. The main varieties are hill rice and swamp rice. The former is sometimes grown on highlands under extremely high rainfall, such as in parts of India; the latter is much more important, and may be grown on hills, too, provided the swamp is artificially

8 *Oryza sativa.*



Map 20.—RICE AND OATS. Solid black and cross-hatching show the respective major areas. For oats see fig. 16. Notice the boundary between the areas where there is only one rice crop a year, and the warmer and wetter areas where two crops a year are obtained.

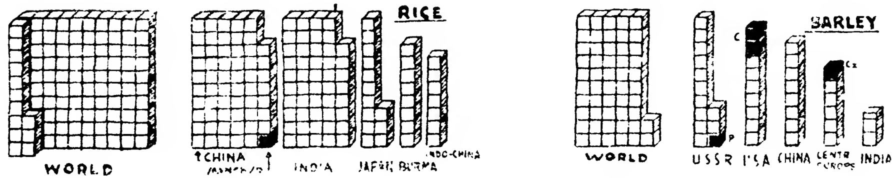


Fig. 11.—RICE AND BARLEY. Central Europe stands for Germany and Czechoslovakia (Cz.). P. stands for Poland. One cube is 1,000,000 metr. tons.

The nutritive value of the various cereals is still controversial. Maize-eating peoples find a good supply of vitamin A in yellow maize. Vitamin B_1 is abundant in barley, oats and maize, whereas barley and rice seem to be relatively rich in nicotinic acid. Oats, wheat and barley are particularly rich in calcium and phosphorus, oats and wheat in iron as well. The carbohydrate and protein value is high in all cereals. Modern milling methods greatly reduce the protein content, and the vitamin contents fall to very low values, thus deteriorating the nutritional standards of all peoples of Western civilization. To obviate this, some countries have recently adopted uniform types of flour either containing at least 85 per cent. of the matter found in the whole grain, or enriched by adding three of the B vitamins and iron, plus calcium and D vitamin if required.

created by terracing. This is a work which changes the whole landscape and requires the work of generations, but the density of Javanese, Chinese and Filipino populations is such, that the issue is either terracing or starvation. Great river flats enriched by the silt carried down through ages past are the great asset of Indian, Indo-Chinese and Chinese rice cultivation; the fields are easily flooded, and the soil is very fertile.

In Asia the seedlings are usually grown very densely until they reach sufficient size to be transplanted. This work is done by hand, and requires great care and a certain skill; the fields are flooded either before or after transplanting, and must remain under water a few inches deep until harvest time. Weeding has therefore to be carried out in the water and implies working under trying conditions. These operations are economically possible only where the crop is grown for subsistence. In North America and Australia where other economic and social conditions prevail, some operations are speeded up, and sowing and harvesting are done by machine, after the field has been drained.

Generally rice-growing requires the whole agricultural year, but in South-Eastern Asia higher temperatures make it possible to have two crops a year. Within a narrow belt which is intermediate between the areas yielding one and two rice crops a year respectively, rice is grown in summer and wheat in winter on the same fields, which are drained for wheat-growing.

Rice is by no means limited to monsoonal lands, where, however, tradition and a very high yield

per acre make it the main crop; it may grow wherever there is rich soil, not necessarily river-borne, and where the summer is rather hot. Thus in Italy, in the Middle Po Valley, rice reaches its northernmost extension, mainly because of the rather hot summer brought about by the continental mass of Europe. In Japan, thanks to the Kuro-Siwo, rice reaches also fairly high latitudes.

The greatest rice producers are China, India, Burma and Japan. There is very little export trade going on, because each of these countries except Burma is so densely populated that it cannot afford to sell any part of its crop. Few countries outside monsoonal Asia have become rice-growers. Brazil and the United States have a rather fair production, while Italy and Spain have a small production on irrigated lands. Australia grows her rice requirements under irrigation near the Murrumbidgee.

The polished white rice usually seen in shops and homes is only a very small part of the World's rice; most rice is traded with the husk, and is known under the name of paddy, or padi.

Before being consumed, rice is freed from the husk and is then known as brown rice. In countries inhabited by Europeans rice is always cleaned of its brown skin and is called white rice.

White rice is usually polished by a light coating with a special mixture, and enters the trade in the form Europe, America and Australia know it.

Rice is of paramount importance as human food, above all because it is largely consumed in countries where very little meat is consumed.

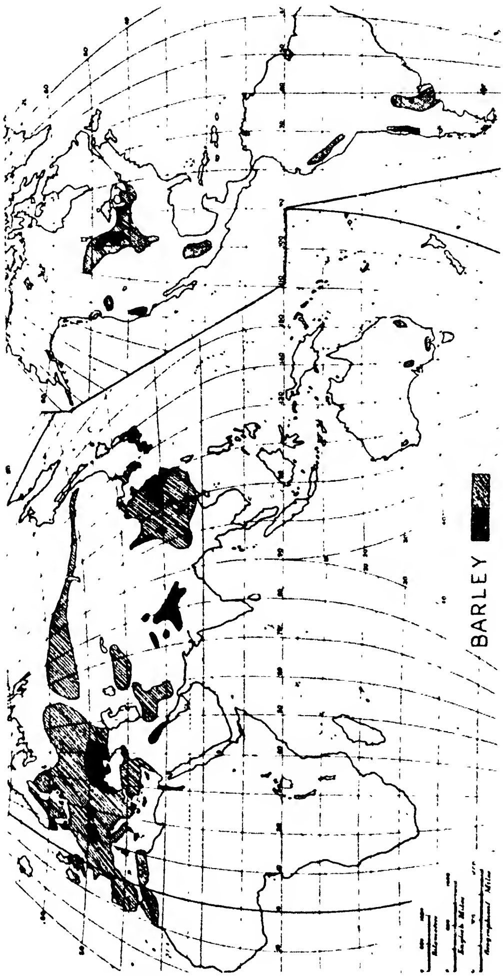
The chief secondary products obtained from

rice are starch and alcohol. One must also mention the main alcoholic drink in South-Eastern Asia, rice-brandy, which is called sake in Japan. Long ago the Chinese invented the making of paper from rice straw, and even now this remains perhaps the finest type of paper, although much "rice paper" is obtained from quite a different plant.[9]

As human food, barley[10] comes next to rice, although other grains are produced in greater quantities (fig. 8). It has a distinct advantage over most other grain plants in that it requires much less moisture and it grows very rapidly. The first characteristic has enabled many Mediterranean peoples to use barley at a very early stage of their development. Even now, the dry plateau of Algeria and Morocco produces much barley without which Arabs and Berbers could not live—no other grain could be produced under such dry conditions. The second characteristic enables northerly countries such as Canada or Sweden to grow as much barley as they need.

Unlike wheat and rice, a certain part of barley production is not used directly as human food: nearly half of it is devoted to beer production, and small quantities are further distilled to yield whisky. Malt is also obtained from barley. A substantial part of the World's barley crop is, however, used, like wheat, for the making of bread.[11]

9 *Broussonetia papyrifera*, a small tree of south-eastern Asia.
10 *Hordeum sativum*.
11 Six-row barley (*Hordeum sativum hexastichon*) is perhaps the oldest cultivated sub-species, and is used, like the less frequent four-row barley (*H. sativum vulgare*) for baking and cooking and animal food as well. A Californian variety of six-row barley is used in the making of light sparkling beer. Most malting barley belongs to the sub-species *H. sativum distichon*, with two rows of grains in the ear.



Map 21.—BARLEY. Note the extension of barley fields into dry as well as cold lands. Major areas are shown in black.

The greatest barley producer is the Soviet Union, where barley is used mainly as food. Much less is produced in the United States and Germany respectively, where it is used mainly for brewing.

Rye[12] is grown exclusively for human food, and mostly used for the making of bread. The great advantage of this grain over wheat is that it can grow on very poor soils, even if they are leached and sour, or sandy, and even if the climate is cold, because of its very quick growth. This great advantage has made it possible for the Soviet Union to extend grain production to rather high latitudes, where no other grain could grow; the Soviet rye belt produces almost all the World's total. Smaller quantities are produced in Central Europe, where rye, however, is still more important than barley. North American production is very small, and is due mainly to tradition carried on by Central European immigrants for generations after their arrival.

Rye straw is most suitable to stuff horse collars, pack-saddles, etc.

Maize[13] is a giant grass, which was the basis of Central American civilisations, and was brought to the Old World by the Spaniards. Its main areas of cultivation are now in newly populated areas of the Americas where most of it is grown as feed for cattle and pigs; much is grown for human food in more densely populated countries.

Although there is only one species of maize, several varieties have been obtained by century-

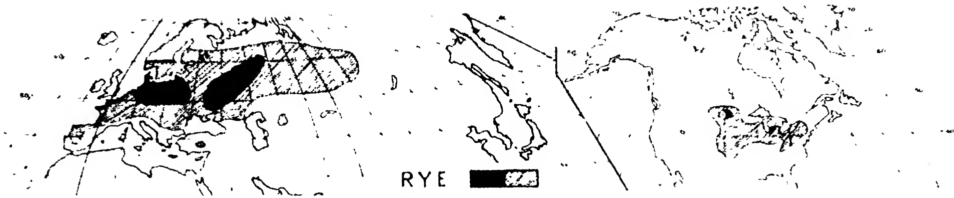
12 *Secale cereale.*
13 *Zea mais*, called "corn" in the United States and "mealies" in South Africa.

old breeding. From the point of view of colour, there are red, yellow and white types; for flavour, starchy and sweet. The great groups of varieties are flint maize, dent maize and flour maize; the minor groups are sweet "corn" and pop "corn." Flint maize contains much horny starch. Dent maize has less horny starch, and the shrinkage of the soft starch when drying produces a characteristic dent in the grain. Flour maize contains no horny starch.

The climatic requirements for maize-growing are a moist warm spring and a hot summer. When maize is grown for stock feed in North America it may be allowed to grow until the grain is ripe, and animals are fed on the grain; sometimes it is better to use also the green parts as feed, and either the whole plant is cut down and used as fodder, or it is "hogged down," as the Americans say—pigs are turned loose into the field, and harvest it thoroughly. Maps 23 and 37 show the relationship between maize-growing and pig-raising. What is not shown on maps is the very important migration of North American cattle from the drier pastures of the West, to the fattening maize districts.

When used for human food, maize is generally dried, ground to a coarse meal, and then boiled or baked. Some sweet varieties are eaten slightly scorched, boiled, or even raw, without being previously dried and ground.

Maize ranks now second after wheat and before rice as a world crop (fig. 8). Over half of it is grown in the United States, the rest is grown in Eastern Brazil, China, and the Danubian Basin. Export trade is relatively small; only Argentina



Map 22.—RYE. Major areas black.

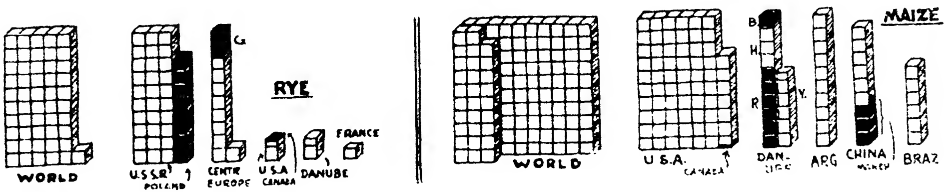
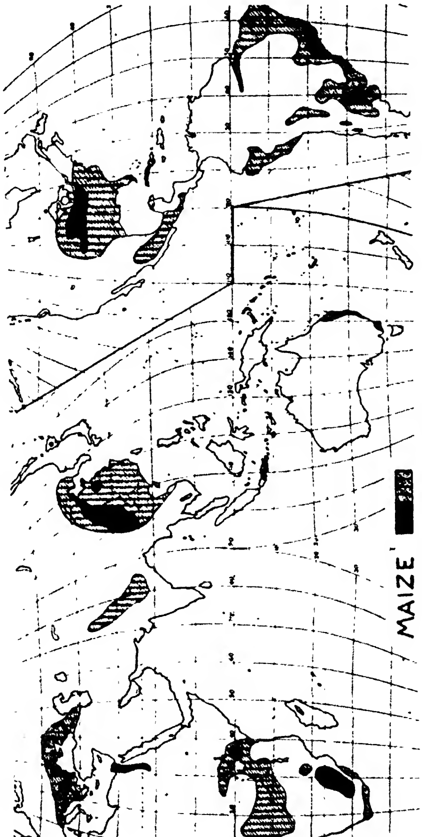


Fig. 12.—RYE AND MAIZE. "Central Europe" stands for Germany and Czechoslovakia (Cz.); "Danube" includes Bulgaria, Hungary, Roumania and Yugoslavia. One cube represents 1,000,000 metr. tons.



Map 23.—MAIZE. The area under maize in Africa is likely to extend considerably. Major areas are shown black.

and some Danubian countries have a regular exportable surplus, which is sent to the dairying districts of Western Europe.

Only North America produces enough maize to afford using some for oil extraction—maize oil is used for human consumption and in several industries. In Latin America a light fermented drink called chicha is obtained from maize.

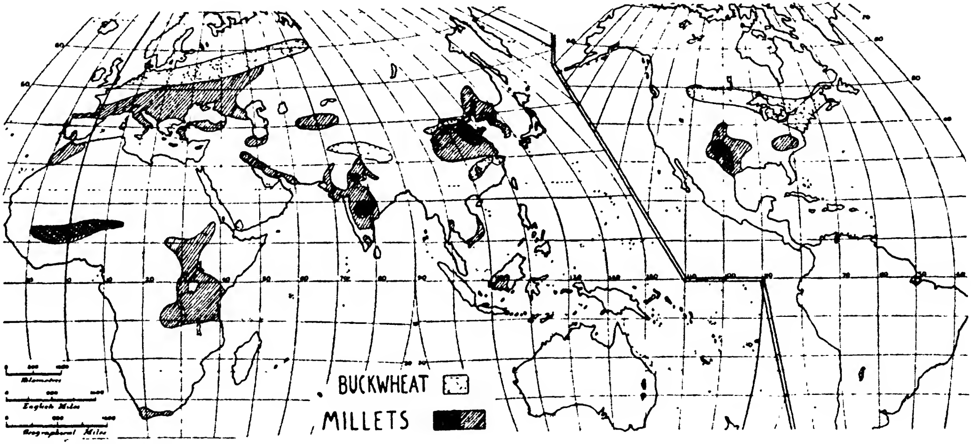
At least a dozen species are included under the name of millet or sorghum. These plants generally grow in dry countries where there is a short rainy period followed by a long drought. Although maize is preferred because of its higher yield, there are many lands where millets and sorghums are grown because there is not enough moisture for a good maize crop.

Millets and sorghums are of vital importance in the drier areas of monsoonal Asia and in many parts of the African savanna, where they are the staple food.

Millets[14] are preferably grown around the Mediterranean and farther east, as far as India, China and Japan. Their grain yields a nutritious meal, and is also used as animal food. The chief species of sorghum[15] is grown from the African savanna to the cold lands of northern China, and many varieties have been developed, including the saccharine ones grown in the United States for the syrup contained in their stems. Another important American development is the selection of

14 *Setaria italica* (foxtail, Hungarian grass or Italian millet); *Panicum miliare* (little millet); *P. miliaceum* (broom or common millet); *P. crus-galli* (barnyard or Japanese millet); *Pennisetum typhoideum* (cat-tail, bajree or pearl millet).

15 *Sorghum halepense* is the wild species; *S. vulgare* the cultivated one, with many varieties (durra in North Africa, kaffir in South Africa, jawari in India, kaoliang in China, milo and feterita introduced into North America, together with the var. *saccharatum* or saccharine sorghum).



Map 24.—MILLETS AND BUCKWHEAT. The distribution of millet (including sorghums) in India should be compared with that of other grain crops, and of the population as well. The area under buckwheat in Central Asia is likely to be greater than shown above.

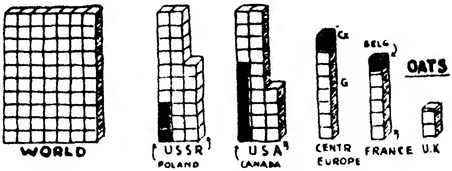


Fig. 13.—OATS. One cube represents 1,000,000 metr. tons. Cz. stands for Czechoslovakia, G. stands for Germany, U.K. for United Kingdom of Great Britain and Northern Ireland.

varieties whose grain can be harvested by machine, thus enabling large crops to be easily handled.

Common millet is grown for its grain and its broom fibres as well.

Like maize, oats[16] are mainly used as stock feed. Since they thrive in wet cold climates, where wheat could hardly grow, they have become the main grain in the diet of North-Western Europe, whence ground and boiled as porridge they have been made known to other lands. Many Scottish articles of food besides porridge are made of oat flour or meal. Most of the World's oats grow, however, in drier countries, where their grains remain much smaller; they are then used for stock feed, principally for horses. The yield and bushel weight of oats vary much more than those of wheat, being mainly determined by the length of the wet season.

The distribution of oats follows very closely that of horses, which in turn does not differ from the distribution of human population in Cool or Cold Regions: the great Eurasian and North American plains are typical oat and horse country (map 20).

16 *Avena sativa:* the wild plant is considered a different species (*A. fatua*).

Buckwheat[17] is one of the less important grains, produced by a small plant which, notwithstanding its name, has nothing in common with wheat or any other cereal. It thrives on very poor, sour or sandy soils: it grows very quickly, so that on high mountains or at high latitudes, where the growing season is very short, it is the only grain that can be grown (map 24). Its yield is very irregular and unreliable. At times buckwheat is sown late in the year after the failure of other grain crops, and its growth is so rapid that it ripens before the cold season sets in. The grain is used as stock feed; in some countries it is ground, and used to make porridge or cakes.

17 *Polygonum fagopyrum.*

IV. VEGETABLES AND FRUITS.

A list of important vegetables and fruits.

Group	Chief Crop	Climatic Requirements	
		Temperature	Rainfall
A. Vegetables:			
Pulses	Soya bean	cool, cold	moderate, heavy
Rootstocks	Beet	cold	moderate, heavy
Tubers	Potato	warm, cool, cold	moderate, heavy
	Sweet potato	warm, hot	heavy
	Manioc	hot	heavy, very heavy
Pith	Sago	hot	heavy, very heavy
B. Fruits:			
Core	Apple	cool, cold	moderate, heavy
	Pear	warm, cool	moderate, heavy
Citrus	Orange	warm	moderate
	Grape fruit	warm	heavy
	Lemon	warm	moderate
Soft	Fig	warm	moderate
	Grape	warm	moderate
Tropical	Date	hot	very low
	Banana	hot	heavy, very heavy

Pulses is a general term used to designate all types of leguminous plants, the pods or seeds of which may be eaten by man or beast. They are generally small plants, often creepers, but there are also a few trees.

Chick peas[1] and lentils[2] are still rather largely cultivated in the semi-dry regions of the Mediterranean, spreading eastwards as far as India. By far more important are broad beans[3] which were originally grown around the Mediterranean, and

1 *Cicer arietinum.*
2 *Lens esculenta.*
3 *Vicia faba*

french beans[4] which may have been discovered in Mexico; french beans require a good supply of water and not too much heat, but have now been introduced into very many regions. Peas[5] are now grown under the most diverse climatic conditions, provided sufficient water is available. Therefore all these pulses may be divided into two main groups: those which thrive in semi-dry Regions, and those that require the rainfall of wet Regions. All of them are used as human food, some with and some without pod, some fresh and others dry.

The most important pulse is the soya bean[6], grown mainly in Northern China and Manchuria (map 31), and now introduced with great success into the climatically similar areas of North America. In Asia it is used mainly as human food, and as a source of a valuable oil; some varieties are used also as stock feed. In America it is used as a source of oil, and the green parts and what is left after the extraction of the oil, are used as fodder. Its main climatic requirement is a rather long warm wet season.

Lupins,[7] which have been grown round the Mediterranean for fodder, and seldom for human food, are less important. Now they have been introduced into many countries with west-coast or other temperate climates, because they can grow on very poor soils, which they enrich—like all pulses—with nitrogen compounds.

4 *Phaseolus vulgaris;* the runner bean is *Ph. multiflorus.* The Lima bean, *Ph. lunatus,* comes from South America and is now well known in the United States. Minor species of beans are the hyacinth bean = *Dolichos lablab* of Egypt, the asparagus bean = *D. sesquipedalis* of Eurasia, and the eyed bean = *D. unguiculatus* of the Mediterranean.

5 *Pisum sativum.*

6 *Glycine soja;* according to more recent classification, *Soja hispida.*

7 *Lupinus hirsutus* (blue lupin), *L. albus* (white lupin), *L. luteus* (yellow lupin), *L. angustifolius* (New Zealand blue lupin).

Much less important are the various carob[8] trees of the Mediterranean, Mexico and Texas, producing pods used as stock feed.

It is impossible to mention at length all other plants used for human food in many different regions. The most important group (after pulses) includes cabbages[9], cauliflowers[10], broccoli[10], kohl rabi[10], turnips[11], rapes[12] (map 31), and mustard[13], all very closely related plants. Cabbages grow under the most different climatic conditions, and thrive where it is too cold for almost any other cultivated plant but rye; hence their economic value in Northern Eurasia. There are many other edible green vegetables but space does not permit their enumeration here. All of them have only a local value because they cannot be transported over great distances unless they are carried by express goods trains, as is done in parts of the United States and Central and Southern Europe, or unless cold storage is available; they may be also canned or dried. The most modern drying process is called dehydration.

Beets[14] have become very valuable since a special variety has been evolved, which yields sugar (map 27).

8 *Ceratonia siliqua* of the Mediterranean, *Prosonis* sp. v. or American mezquite (*meth-ki-te*).

9 *Brassica oleracea*.

10 *B. oleracea var.*

11 *B. campestris*, the Swedish turnip or rutabaga; and *B. rapa*, the turnip.

12 *B. campestris* (smooth summer rape). *B. napus* (rough winter rape).

13 *B. nigra* (black mustard) and *B. alba* (white mustard).

14 *Beta vulgaris* The silver beet, *Beta cycla*, is grown for its leaves especially in countries which are too warm to grow successfully the spinach, *Spinacia oleracea*. Other world-known vegetables are lettuce = *Lactuca sativa*, with *L. scariola* as its Asiatic wild counterpart; endive = *Cichorium endivia* and chicory = *C. intybus*; celery = *Apium graveolens* and celeriac = *A. g. rapaceum*; carrot = *Daucus carota*; parsnip = *Pastinaca sativa* and radish = *Raphanus sativus*. Other vegetables are less widely grown for various reasons. *Asparagus officinalis* is best known in the mildly cold and oceanic Regions of Europe. The edible thistle *Cynara*

The most important tuber is the potato[15], which is still grown in its original home on the high Andes, where it is the only locally-produced food. In new and climatically milder environments the plant has been improved very much. Now it yields enormous crops per acre in the most different Regions, from Northern Europe to Palestine, from North America to Australia. Its main requirement is moisture. It is mainly a European crop, the only large production outside Europe being in the Cold Regions of North America.

Although most of the world crop is used as human food, large quantities of potatoes are used in the manufacture of starch and of ethyl alcohol.

The tomato[16], a close relative of the potato, is grown for its fruit; the area of its cultivation has increased greatly of late years, and considerable export takes place when suitable transport is available.

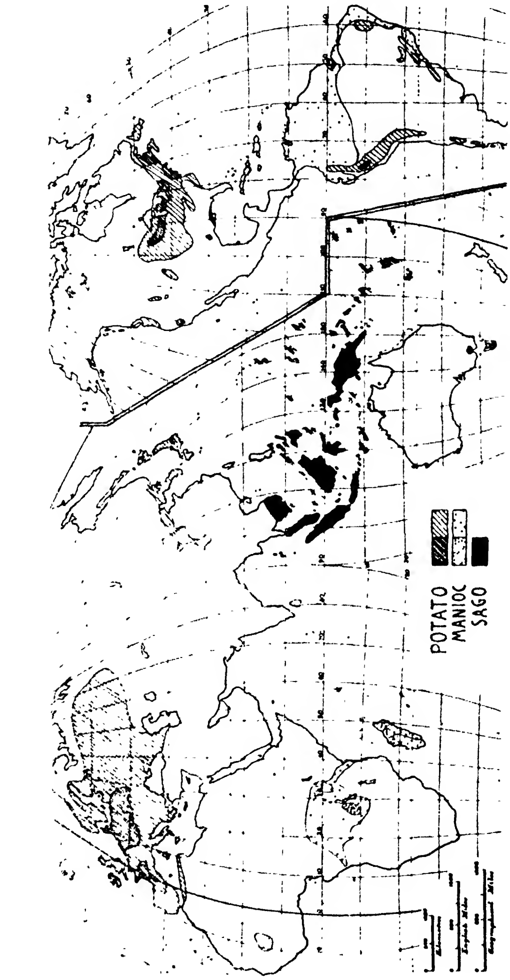
Sweet potatoes[17] are grown in the warmer parts of temperate countries, where potatoes might not grow satisfactorily. In wet hot coun-

cardunculus and the artichoke *C. scolymus* are usually grown around the Mediterranean. The "Jerusalem" artichoke *Helianthus tuberosus* is the tuber of a sunflower, of little food value and seldom cultivated. Rhubarb, *Rheum rhaponticum* and *R. undulatum*, is especially grown in oceanic and mildly cold Regions. Okra, *Hibiscus esculentus*, is sometimes grown for its pods in the East-coast Region of North America. The egg plant or aubergine, *Solanum melongena*, is grown around the Mediterranean and farther east. Watercress, *Nasturtium officinale*, is a minor vegetable of rainy countries. Other plants may hardly be termed edible vegetables: horseradish = *Cochlearia armoracia* and sorrel = *Rumex acetosa* prefer oceanic or mildly cold climates; parsley = *Petroselinum hortense*, peppermint = *Mentha piperita* and *M. viridis*, rosemary = *Rosmarinus officinalis*, sage = *Salvia officinalis*, thyme = *Thymus vulgaris*, and marjoram = *Origanum maiorana* grow equally well in any temperate climate, only varying in the amount of water they require. *Psalliota campestris* is the only cultivated mushroom.

15 *Solanum tuberosum* and other less important species.

16 *S. lycopersicum;* according to other authors, *Lycopersicum esculentum*.

17 *Ipomaea batatas*.



Map 25.—POTATOES, MANIOC AND SAGO. Potatoes yield more energy per acre than any other food crop, hence the present distribution of potato fields in the overcrowded areas of Europe. The distribution of sweet potatoes cannot be shown because of lack of information.

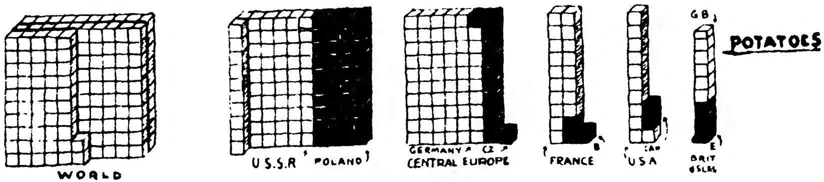


Fig. 14.—POTATOES. One cube represents 1,000,000 metr. tons. Cz. stands for Czecho-slovakia, B. for Belgium, Can. for Canada, G.B. for Great Britain and Northern Ireland, E. for Eire.

Peoples living in cold climates are able to draw ample supplies of vegetable protein from beans of various types; soya beans also contain fat. In the same climates beans, potatoes, beet roots and peas supply large amounts of carbohydrates. The starchy foods of hot climates (tapioca, sago, sweet potatoes and yams) mainly consist of carbohydrates and water. Green vegetables are poor in carbohydrates, but well endowed with vitamins. In cold climates the chief vegetable sources of vitamins A and B, calcium, iron and phosphorus are beans, peas, broccoli, spinach, turnips; the calcium contained in spinach is however unavailable to man. In warm climates carrots, tomatoes and silver beet are rich in vitamins A and B. Little is known of the vitamin content of tropical vegetables.

tries, manioc[18] is grown; it is a shrub which yields poisonous tubers. The poison is easily washed out, and the starchy product thus obtained is known as tapioca or cassava.

In West Africa, the Antilles and the Pacific Islands various species of yams[19] are grown, plants which yield very large edible tubers.

Bulbs are much less important than tubers, except onions[20], which are grown on light soils where plenty of water is available; the main producing countries are Egypt and the Netherlands.

The pith of a palm growing from Malaya to New Guinea and many nearby islands is known as sago[21]; it is the main food in New Guinea and many islands and small quantities are exported. Arrowroots[22] are the rootstocks of various kinds of plants which grow in hot regions; they yield a starchy substance.

Apples[23] thrive in cool and cold high latitude Regions, such as North America and Central Europe; the Southern Hemisphere is at a disadvantage in this respect because its corresponding Regions are very small. Apples keep very well in cold storage and considerable quantities are exported; exports from the Southern Hemisphere reach European markets when there are no apples

18 *Manihot utilissima* is the chief species; *M. palmata* and other species are also cultivated.
19 *Dioscorea sativa*, *D. papuana* and other species.
20 *Allium cepa*, the leek (*A. porrum*), the shallot (*A. ascalonicum*) and the garlic (*A. sativum*) are also cultivated.
21 *Metroxylon laeve* and *M. rumphii*.
22 *Maranta arundinacea*: English "arrowroot" is obtained from potatoes. In most Pacific Islands *Colocasia esculenta* (taro) is grown for its rootstock which is starchy; in the southernmost islands this is the only food plant, it being too cool for sago and coco palms. The Egyptians and the Indians know since time immemorial another species of taro, *C. antiquorum*.
23 *Pyrus malus*; over 1,600 varieties have been derived from the original plant, the crab apple. See Bush, "Tree Fruit Growing" (Penguin).

available from local orchards. Apples are now dehydrated to save space for overseas exports.

Pears[24] are less widely grown, and even less so are quinces[25]. The former grow in much the same regions as apples, although they can endure less cold; the latter require warmer temperatures. Pears are often canned for export, because they do not keep well in cold storage; small quantities are dried.

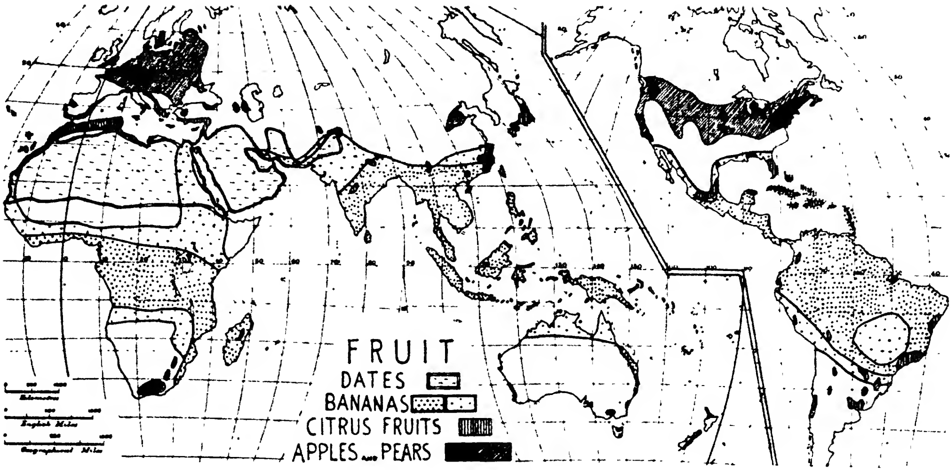
Plums[26] are perhaps the most widely grown type of stone fruit, there being many different varieties, from the sugary round plums from Japan and China to the oblong prunes of the Danubian Basin. Most of these varieties have been greatly improved and are now grown in the most different climates. Prunes can be easily dried.

Cherries[27] require the same mildly cold climate as prunes.

Peaches[28], apricots[29] and almonds[30] are grown over most temperate regions, better perhaps under winter rainfall. The problem of preservation and transport has been solved for peaches and apricots by drying or canning. Almonds keep very long because the only edible part of the fruit is the dried kernel. They yield a valuable medicinal and cosmetic product, almond oil.

The main production of oranges[31] occurs now in California and Florida, closely followed

24 *Pyrus communis.*
25 *Pyrus cydonia.*
26 *Prunus domestica* is the original stock.
27 *Prunus cerasus*, derived from the wild cherry (*P. avium*).
28 *Prunus persica;* the cultivated nectarine is a variety of peach.
29 *Prunus armeniaca*, very important for its high pro-vitamin A content.
30 *Prunus amygdalus*, with three chief varieties, namely sweet, bitter, and thin-shelled.
31 *Citrus aurantium*, an excellent source of vitamins A, B, and C.



Map 26.—FRUIT. The banana (including the plantain) is the most widely grown fruit plant, possibly because of the easy reproduction of the plant and its quick growth. Only few areas export bananas; the chief trade has developed between the Antilles and Central America (exporting countries) and the United States and Western Europe (importing countries). Major banana lands are closely dotted. The extreme limit of the date palm is shown, but within this limit the plant is very irregularly distributed—map 18 should be studied. The very small major (cross hatched) areas under apple orchards yield relatively enormous crops.

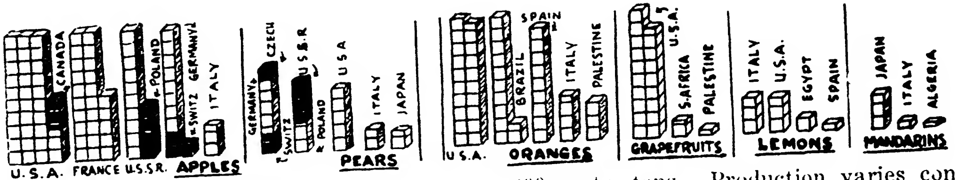


Fig. 15.—FRUIT. One cube represents 100,000 metr. tons. Production varies considerably from one year to the other.

The peoples of the Mediterranean and the Sahara are perhaps at an advantage, because dried fruits, such as raisins, currants and dates contain the highest percentage of calcium and energy-giving carbohydrates, and grapes have one of the highest percentages among fresh fruit. In hotter and wetter climates there is the banana, with the highest carbohydrate content among fresh fruit, and the pineapple. In cooler and wetter climates fruits are poorer in carbohydrates, cherries, apples and pears being inferior to fresh grapes. Thanks to either peanuts, almonds, or walnuts, almost every region has a rich supply of vegetable fat, protein, iron, phosphorus, calcium and vitamin B_1 (thiamin or aneurin); raw peanuts are the richest source of this vitamin among fruit. Next best, but far inferior, sources of iron and phosphorus are dried prunes, raspberries and loganberries in cool climates, mulberries, dried apricots, raisins and figs in warm climates, and passionfruit in hot wet and the date in hot dry climates. Mangoes are very rich and bananas rather rich in vitamin A, guavas very rich and mangoes and papaws rich in vitamin C. In warm climates apricots, melons and yellow peaches are the best source of vitamin A and of some of the B vitamins, whereas citrus fruits supply vitamin C and calcium. Dried prunes are the only good source of vitamin A among cool-climate fruits; apples supply the B vitamins in not very large quantity. Though this outline is generalized, it may be said that cool climates are at a disadvantage as far as the protective contents of fruit are concerned, and tropical fruits are poor in calcium.

by the East-coast Region of Brazil, and the countries around the Mediterranean.

Grape fruits[32] come next in importance since they have met with such great favour in the United States; they require a slightly warmer climate than oranges. Lemons[33] are grown in about the same quantities in California and around the Mediterranean (map 26).

Less important citrus fruits are mandarins[34], grown especially in Japan; limes[35], grown in the Antilles for their juice; citrons[36] grown in Sicily and Greece and used to flavour cakes; bergamots[37] grown in Southern Italy for their scent, which is used in the making of eau-de-Cologne and other perfumes.

Figs[38] grow in most Warm West-coast Regions; they are eaten generally fresh, but large quantities are dried and exported from the Eastern Mediterranean. Grapes[39] are also consumed fresh, but some special varieties are dried, and others are used to make wine (map 28). Dried grapes are known as raisins, of which sultanas and lexias are the best known varieties; currants—which are also dried grapes—are generally considered apart. Although vines are grown in Central Europe, their best place is in warmer countries; dried grapes can be produced only where sunshine is bright and reliable.

32 *C. decumana*, also called shaddock. Some vitamins B and C.
33 *C. limonum*. No vitamin A, some B and much C.
34 *C. japonica*, sometimes called tangerine—a name applied to a small flat orange. Rich in vitamins A and C; poor in B.
35 *C. limetta*.
36 *C. medica*.
37 *C. bergamia*.
38 *Ficus carica*. The fruit is rather rich in phosphorus.
39 *Vitis vinifera*, generally grafted on American vines, such as *V. rupestris*, *V. riparia*, and *V. berlandieri*. *V. labrusca* is an American species which is now seldom grown. Currants are rich in calcium.

Chestnuts[40] are dried, and eaten boiled or roasted. They may be ground, and the meal so obtained is cooked in various ways. They have a great food value in hilly districts of Temperate West-coast Regions, where no other fruit trees would grow. They generally form forests, whereas walnut[41] trees grow isolated, and hazel[42] shrubs thrive further up the slopes in the same Regions. Hazel nuts are obtained at lower levels in cooler Regions, Brazil nuts[43] are gathered in South American equatorial forests. Queensland nuts[44] are becoming increasingly known; they come from the tropical forests of Australia.

Many kinds of melons[45] are extensively grown in warm or hot Regions.

Loquats[46] require a warm climate with a moderate rainfall. Medlars[47] grow in cool or cold countries; their fruit is of little value. Persimmons[48] are grown in the Warm East-coast Regions of North America and Asia. Pomegranates[49] grow around the Mediterranean and in countries with winter rain. Mulberries[50] exist in three different species, with white, red or

40 *Castanea sativa.* The Japanese *C. crenata* is grown for its very large nuts; the North American *C. dentata* is preferred for its flavour. The small fruits of the North American chinquapin, *C. pumila*, are also used for human consumption.

41 *Juglans regia.* Extremely rich in calcium, iron and phosphorus.

42 *Corylus avellana.*

43 *Bertholletia excelsa.*

44 *Macadamia ternifolia.*

45 *Cucumis melo;* the water melon is *Citrullus vulgaris.* The cucumber is *Cucumis sativus,* and the three cultivated species of pumpkins (with countless varieties) are *Cucurbita pepo, C. maxima* and *C. moschata;* marrows and squashes are hybrids or varieties.

46 Also called Japanese quince or medlar (*Photinia japonica*).

47 *Mespilus germanica.*

48 *Diospyros virginiana* or Virginia date plum is the American species, *D. kaki* is the Asiatic one, sometimes called Japanese date plum.

49 *Punica granatum;* the astringent rind is sometimes used for tanning.

50 *Morus alba* bears white berries; those of the common or black mulberry (*M. nigra*) are dark purple. The American red mulberry (*M. rubra*) is seldom grown.

purple berry; they require a warm or moderately cool climate, with summer or winter rain. Raspberries, blackberries, dewberries, gooseberries, currants (white, red or black)[51] are all cultivated in cool or cold lands, where they are frequently found wild. Huckleberries, bilberries and cranberries[52] grow in the cool parts of Europe and North America. Strawberries[53] are preferably grown in cool areas, although they may be cultivated in warm areas in sheltered locations. Cape gooseberries[54] grow in warm countries.

Dates[55] are known dried, although where they are produced they are eaten green. They are of vital importance in the Desert Regions of North Africa and Arabia (map 26), because they are a sugary nourishing food, which is not bulky and keeps indefinitely.

Bananas[56] are the only widely cultivated and largely exported tropical fruit. They grow in almost all the rainy hot lands where primitive agriculture prevails. They often replace the plantain[57], which is similar but less valuable, and was once grown very extensively. Large plantations of bananas have been established, and a steady

51 Raspberry = *Rubus idaeus*; blackberry or bramble = *Rubus fruticosus*; dewberry = *Rubus caesius*, gooseberry = *Ribes grossularia*, currant = *Ribes nigrum* (black). *R. vulgare*, *R. rubrum*, *R. petraeum* (whose hybrids bear white or red berries).

52 Huckleberry = *Gaylussacia resinosa* (common huckleberry), *G. brachycera* (box huckleberry), *G. dumosa* (dwarf huckleberry); bilberry or whortleberry = *Vaccinius myrtillus*; American cranberry = *V. macrocarpus*; the European cranberry, *V. oxycoccus*, bears small sour red berries.

53 *Fragaria vesca* of the cool areas of Europe grows wild and its small berries are gathered; *F. chiloensis* of Chile and *F. virginiana* are cultivated, often hybridised.

54 *Physalis peruviana*.

55 *Phoenix dactylifera*.

56 There is a short but interesting note under the heading, "Why Bananas Have no Pips," in "Science and Everyday Life," by Haldane (Penguin Books). The botanical name of the banana is *Musa sapientum*. A smaller plant is *M. cavendishi*.

57 *Musa paradisiaca*.

V. BEVERAGES.

Milk is by far the most important beverage in both nutritional value and quantity produced, but being an animal product it will be dealt with later on (Chap. XII).

Chief beverages of vegetable origin.

Beverage	Climatic Requirements	
	Temperature	Rainfall
A. Non-alcoholic		
coffee	warm, hot	moderate, heavy
tea	warm, hot	moderate, heavy
cacao	hot	heavy
B. Alcoholic		
wine (grape)	warm	moderate
beer (barley)	warm, cool, cold	low, moderate
cider (apple)	cool, cold	moderate, heavy

Coffee is the most widely consumed non-fermented drink of vegetable origin. It is obtained from the roast seeds (often called "beans") of a small evergreen tree; the berries are picked, stripped of their pulp, and the seeds so obtained are peeled. After being roasted they are ground. Coffee requires a very warm climate with a regular rainfall, rich and well-drained soils, and shade. The original home of the main species of coffee[1] was on the highlands of southern Abyssinia; plantations have been established under similar conditions mainly in Brazil and other parts of South America, Central America and the Antilles,

1 *Coffea arabica*. The chief substitute is made from the rootstock of *Cichorium intybus*, the common chicory; this is perhaps the only substitute that goes under its own name.

and Java. When most plantations in Java and Ceylon were destroyed by a pest, another species of coffee[2] was introduced from the West African Savanna Region. The flavour of coffee varies very much according to many factors and some countries with a small production have established a sound reputation for the high quality of their coffee.

Coffee consumption is very high in the coffee-producing countries of Latin America, in the United States, and in continental Europe as far east as Poland.

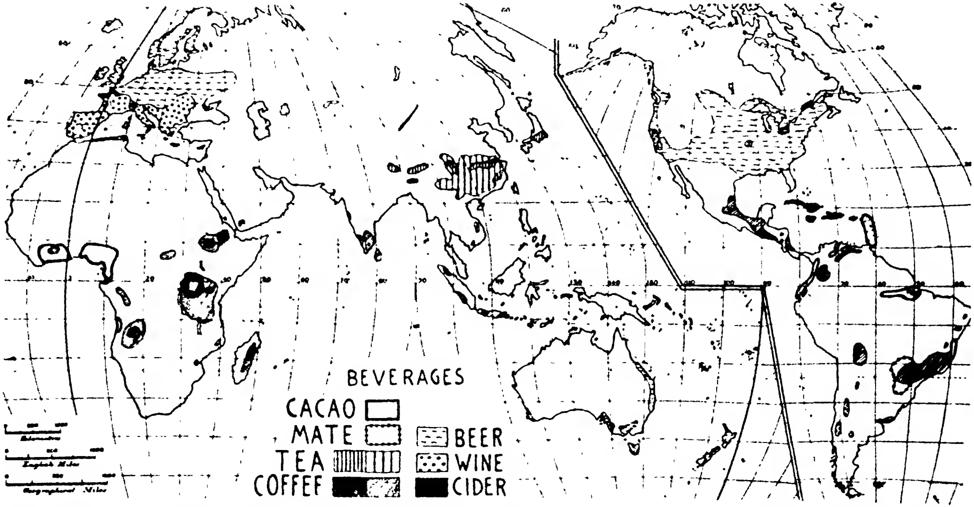
Tea[3] is obtained from the leaves of an evergreen shrub growing mainly on the monsoonal highlands of Assam and China, and now introduced into all Asiatic lands with similar climate. The shrub requires very warm moist summers, and rich soil with good drainage. The leaves are picked when young, and treated differently to obtain either green or black tea. To produce black tea the leaves are fermented before being dried, to produce green tea they are simply dried.

Most exports to Inner Asia are in the form of tablet or "brick" tea, which is obtained by pressing tea dust; it is most convenient for pack transport. In Japan some "flat" tea is produced by keeping tea leaves flat instead of rolling them.

Tea is consumed mainly where it is grown; most exports go to British countries, the Soviet Union, and the United States, where it is however, used less than coffee.

The cacao[4] tree ("cocoa" is a misnomer and leads to confusion with coco) requires a very hot

2 C. *liberica*.
3 *Camellia theifera:* the chief cultivated varieties are *C. theifera viridis* and *C. theifera bohea*.



Map 27.—BEVERAGES. Coffee and cacao are grown over very small areas (see also fig. 7): the very important West African (Nigerian) plantations have been established quite recently. Note the extremely small area in Arabia, where the true "moka" grows. The famous Ceylon tea is also grown over a limited acreage. The oasis vineyards of Mendoza and Tucuman (Argentine) should be identified on a general map. Major tea and coffee areas are shown by closer shading.

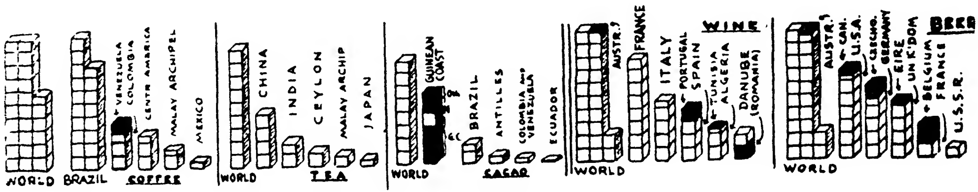


Fig. 16.—BEVERAGES. Most of the coffee and tea of the Malay Archipelago are actually grown in Java. G.C. stands for Gold Coast, and N. for Nigeria. One cube represents 100,000 metr. tons of coffee, tea or cacao, or 10,000,000 hectolitres of wine or beer.

and moist climate and very deep soil, such conditions as are found in the Amazon Basin—home of the tree—and in West Africa, which is now the main centre of production. Like coffee trees, cacao trees require sufficient shade. The tree produces very large fruits containing many beans, which yield much useful fat, known as cacao butter. After most of the cacao butter has been extracted, the beans are ground to obtain the usual cacao powder, from which "cocoa" and chocolate are made.

In many countries cool drinks are obtained from lime, lemon or orange juice, or from soda water flavoured in various ways. Soda water is plain water holding carbon dioxide under pressure (soda has nothing to do with it now). The most widely consumed North American cool drink is partly made of cola juice. Cola[5] is a plant originally grown in West Africa, and now extensively grown in the Antilles and parts of Brazil.

Almost everywhere man seems to have evolved a taste for fermented or alcoholic drinks. These can be divided into two groups, mild and strong. From some plants only mild drinks can be obtained, from others only strong ones; some plants may yield both.

Wine (map 27) is obtained from grape juice; its alcoholic content varies according to the quantity of sugar which is present in the grape, and which is mainly determined by sunshine. Hence wines of sunny lands such as Italy or Greece are

4 Genus *Theobroma*, with a score of different species. *Th. cacao* yields a first-class product, but is rather sensitive to parasites and diseases; it is cultivated far less extensively than *Th. leicocarpa*, which is hardier, although its cacao is less valuable. *Th. sphaerocarpa* and *Th. pentagona* are seldom cultivated; when they grow wild their fruits are gathered.

5 *Cola acuminata*.

much stronger than wines of other lands, such as France or the Rhineland. Wines with too little sugar or alcohol turn into vinegar by a further fermentation. There are very many types of wine varying in colour, density, alcoholic content, and flavour. For this reason, quantity alone is of no value in comparing wine-producing countries; French production is not only larger than Italian production, but of much greater value because of its higher standards. Algeria produces just less than Spain; its wines are used for blending with French wines, which often lack alcoholic strength.

There are hundreds of types of wines; the most widely known are champagne and burgundy from the corresponding French districts, and claret from near Bordeaux; Asti, Chianti (*kyanti*) and marsala from the corresponding places in Italy; sherry from Jerez (*hereth*) in Spain; port from Oporto in Portugal; hock from Mannheim, and moselle from the basin of the Moselle; and tokay from Hungary. New wine-producing countries generally try to imitate these well-known types, instead of evolving their own brands.

Beer is now produced in larger quantity than wine. It is obtained from sprouted barley, treated with hops to give it a bitter flavour. There are many types of beer which vary more according to market requirements than according to climatic factors. Climate actually determines the distribution of beer itself, which is produced in Europe wherever vines could not grow. In newly settled countries, people followed their old country's traditions, and this accounts for the present beer distribution. Now the greatest beer producers are the United States, Central Europe, and the British Isles (map 27 and fig. 16).

Between the wine and beer areas in Europe lies a strip of country where cider is made from fermented apple juice (map 27). The main cider lands are Brittany, Switzerland, southern England, parts of Quebec. Nomad tribes of the Asiatic steppe drink koumiss (*kumis*) made from fermented mare or camel milk. In Africa palm wine is made from the juice of the flower spike of the toddy palm[6]. In South America chicha is obtained generally from maize. The national beverage of Mexico is pulque (*pulke*) made from the fermented sap of an agave[7]. In many a Pacific island an intoxicating drink is made from kava[8] roots. All these drinks have a low alcoholic content.

Among the more alcoholic drinks the most widely known is whisky, distilled from barley, and used mainly in British countries and the United States; brandy is distilled from grapes and is more used in vine-growing lands. In the Danubian Basin there is a small production of prune brandy. Vodka made from grains or potatoes was once largely drunk by Russian peasants; sake is distilled in Japan from rice; rum is produced from sugar-cane molasses in Jamaica, Queensland and many other countries. Distillation of the Mexican pulque (*pulke*) yields the more alcoholic mescál.

6 *Caryota urens*, the wine is often called toddy.
7 *Agave americana*.
8 *Piper methysticum*.

VI. SUGAR, SPICES AND DRUGS.

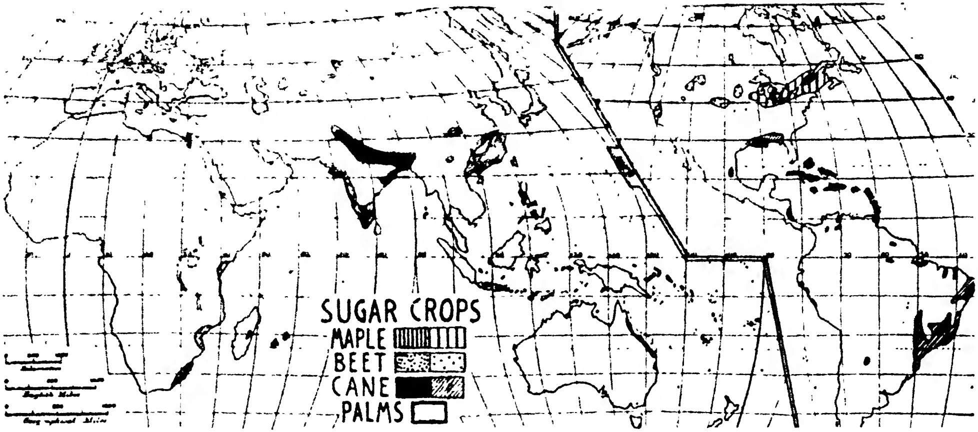
Although sugary juices may be obtained from very many plants, most sugar is obtained from two great and three lesser sources. The great sources of sugar are cane and beet; the lesser sources are palms, sorghum and maple.

Sugar Plants	Climatic Requirements	
	Temperature	Rainfall
cane	hot	heavy
beet	cool	moderate
maple	cold	moderate
sorghum	warm	moderate
palms	hot	low, moderate

The sugar-cane[1] is a giant grass, which is cut to the ground every year, and every year shoots up again a new stalk. Cut canes are crushed at special mills, and the sweet juice so obtained is boiled until it forms crystals of raw sugar; the liquid left is known as molasses, and may be used as an ingredient in stock feed, or as a source of rum. Raw sugar is further treated, and yields refined sugar, treacle and golden syrup. The coarse fibres obtained from crushed cane are used as fuel, but in Australia and other countries a certain quantity is used to make lining materials for buildings.

Sugar-cane requires a rich soil and a hot and moist climate; cane cutting must be done by hand, and is a heavy work under trying tropical weather.

1 *Saccharum officinarum:* several wild species are known and thousands of cultivated varieties have been evolved.



Map 28.—SUGAR CROPS. Note the smallness of the areas which produce most of the cane sugar of the World. The cane-growing oases of the Argentine and the small beet area in Victoria are shown. Saccharine sorghum grown in the United States is shown—with millets and sorghums—on map 24. Closer hatching or dotting, or black, show the major areas. The distribution of the Indian sugar palms is shown; for the distribution of date palms, which also yield a sugary syrup, see map 26.

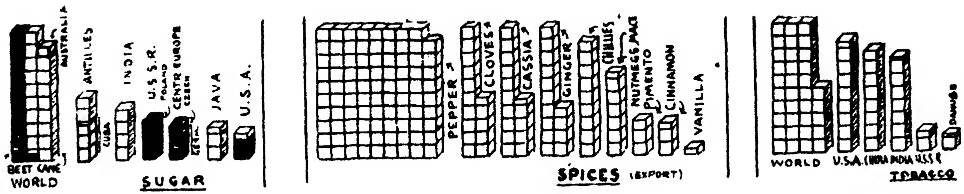


Fig. 17.—SUGAR, SPICES AND TOBACCO. Beet sugar is shown black, cane sugar white. The United States is the only important producer of both. One cube represents 1,000,000 metr. tons of sugar, 1,000 metr. tons of spices, or 100,000 metr. tons of tobacco. Refined sugar is a chemically pure carbohydrate, which is extremely valuable as a source of energy; it is however totally deprived of protective vitamins and this may be the reason why dental caries is rampant in countries where the sugar consumption per head is very high, such as in the United States, Australia and England.

Sugar beet[2] is grown as an annual plant: its root is dug up in autumn, washed and sliced. A sweet juice is obtained from the slices, and the pulp which is left is used to fatten pigs or cattle, or as fertiliser. The juice is boiled and treated as sugar-cane juice, with the same by-products. Beets require a cool moist spring and a warm summer, and grow best on loose well-manured soils. These conditions prevail in Central and Eastern Europe, the British Isles, and north-eastern United States (map 28, p. 140).

Cane sugar is produced in a slightly larger quantity than beet sugar; the latter has become important chiefly thanks to the economic protection which several countries have granted to their sugar-beet industry. The main centres of sugar production are the Monsoon Regions of Asia and the Tropical Forest Regions of the Americas for cane sugar, and Central and Eastern Europe for beet sugar.

Sugar maples[3] grow around the Great Lakes in North America, and yield a sweet sap from which sugar or syrup are obtained. Some varieties of sorghum[4] grown in the Warm East-coast Region of North America yield a sugary syrup. Palms which yield sugar or sugary juices are found in almost every country between the tropics, but their importance is purely local[5].

The importance of spices (fig. 17) has now declined. Pepper is still widely used, and the Moluc-

2 *Beta vulgaris* (a special sugar-yielding variety). The plant is biennial under natural conditions; since the formation of seeds during the second year uses up most of the substances stored in the root during the first year, the plant is usually dug up before the first year is over.

3 *Acer saccharinum*.

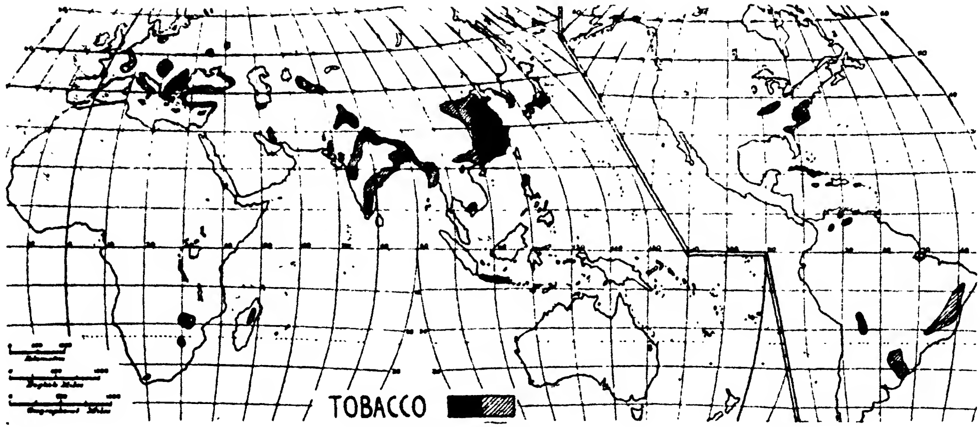
4 *Sorghum vulgare var. saccharatum*.

5 The date palm and the toddy palm may be mentioned; the former's distribution is shown on map 26, p. 126.

cas hold an almost total monopoly of its production. As to quantity, cinnamon comes next, followed by ginger, both largely exported from Southern China. Cloves were once a monopoly of the Moluccas but at present are exported almost totally from Zanzibar. Pepper[6] is obtained from the pepper shrub, whose berries are traded under the name of peppercorns; ground peppercorns are the common pepper, "white" or "black" according to whether it is bleached or not. The "pepper-tree" grown as an ornament in Australia has nothing in common with pepper, except a pungent smell. Cinnamon is obtained from different trees: the true cinnamon[7] is the bark of a tree growing in Ceylon, while cassia[8], which is usually called "common cinnamon," comes mainly from China. Both are traded as pieces of bark ("sticks") or as powder. Ginger[9] is the dried rhizome of a small plant. Cloves[10] are the flower buds of a rather tall tree.

Other spices are red pepper[11] and cubebs[12], while betel[13] leaves are used mainly in India. The Moluccas still enjoy the monopoly of nutmeg and mace production; these spices are the kernels and the skin of the fruit of a large tree[14]. American spices are all-spice or pimento[15], produced in Jamaica from special berries; and vanilla[16] which is the very long and thin pod of a Mexican

6 *Piper nigrum.*
7 *Cinnamomum zeylanicum.*
8 *Laurus cassia.*
9 *Zingiber officinale.*
10 *Caryophyllus aromaticus.*
11 *Capsicum sp. v.*
12 *Piper cubeba.*
13 *Piper betel.*
14 *Myristica moschata.*
15 *Pimenta officinalis.*
16 *Vanilla planifolia.*



Map 29.—TOBACCO. The map shows clearly that the tobacco plant can grow under a great variety of climatic conditions. Actual quantities produced are shown in fig. 17, p. 141.

creeper, now extensively grown in the Islands of Reunion and Mauritius. The rhizome of licorice[17] is exported in fair quantities from Asia Minor; it is valuable for pharmaceutical purposes. There are many other spices, such as fennel, caraways, coriander, aniseed, saffron[18], mustard. Curry which is so widely used in India is a mixture of several spices and other substances.

There are many wild species of tobacco: one[19] from Warm East-coast North America has become very important and widespread. It may be grown in any temperate or mildly cool country, and even in hot countries if altitude tempers the climate; the only absolute limit is set by very severe frosts. At present the main areas of tobacco culture are the Warm East-coast Regions of North America and China, closely followed by some monsoon areas in India, and those parts of the Soviet Union where summers are warm enough. There is some tobacco being grown in every country except the very cold ones, and colour and flavour vary considerably according to climate, cultivation, and treatment. The standard treatment includes curing and drying the leaves, stacking them in special ways, and cutting them suitably. Most tobacco becomes the raw material out of which cigarettes and cigars are manufactured. Valuable products are also obtained from waste tobacco, such as anti-parasitic sprays for plants and animals.

The drug which is contained in tobacco is called nicotine.

17 *Glycyrrhiza sp. v.*
18 Fennel = *Foeniculum vulgare:* caraway = *Carum carui;* coriander = *Coriandrum sativum:* anise = *Pimpinella anisum;* star anise = *Illicium verum:* saffron = *Crocus sativus.*
19 *Nicotiana tabacum.* See fig. 17. p. 141. and map opposite.

There are over 250 drugs being used at present, mainly for medical purposes[20], and they are obtained from very different sources. The most important drug is still opium, which is obtained by incising the fruit of a special type of poppy[21]. Now that opium smoking is forbidden in China, opium is used only to provide the valuable medical drugs which it contains, such as laudanum and morphia. Opium production is now practically restricted to Turkey, Iran and India.

An extremely valuable drug is quinine, obtained from the bark of several species of trees[22] growing wild on the Andes; some of them are now extensively grown in Java; quinine is used against malaria and other tropical fevers.

Valuable medicinal drugs are obtained from coffee and cacao, namely caffeine and theobromine respectively. Cocaine, like morphia, is considered a dangerous drug and is subject to strict government control; it is obtained from the leaves of a plant[23] growing on the high Andes, often chewed by the natives to acquire endurance to physical strain. Cola is used by West African Negroes for similar purposes.

The most powerful vegetable drug is penicillin, first found in a mould[24].

The numbers of synthetically-produced drugs increase almost every day, and several vegetable drugs have already lost much of their importance.

20 Read the chapter, "Drugs," in "Science and Everyday Life," by Haldane (Penguin Books).

21 *Papaver somniferum*, the cultivated counterpart of *P. setigerum*.

22 *Cinchona succirubra*, *C. calisaya*, *C. ledgeriana*, *C. officinalis*. A very satisfactory synthetic substitute for quinine is mepacrine, a recent discovery.

23 *Erythroxylum coca*.

24 *Penicillium notatum*.

VII. VEGETABLE FATS AND OILS.

The whole problem of fat and oil supply is rather difficult to grasp, because technique and trade frequently open new fields, with unexpected and sometimes astonishing results. To mention only one instance: cottonseed oil is not usually edible; the discovery of a simple way of making it edible has changed almost completely the whole American edible fat industry. Tung oil was unknown outside China up to a few years ago; new techniques in paint-making raised it to a very important position among raw materials.

The first question man asks about a fat or oil is whether it is edible; modern industry may ask whether it is lubricating if applied to mechanical devices, or whether it dries or remains fluid if used in paints. There are many other special purposes for which special oils are needed.

Oil Fruit or Seed	Climatic Requirements	
	Temperature	Rainfall
A. Edible:		
coconut	hot	heavy
oil palm	hot	heavy
cottonseed	warm, hot	moderate, heavy
peanut	warm, hot	moderate
olive	warm	moderate
soya bean	cold	moderate
hempseed	cold	moderate
rapeseed	cool, cold	moderate
B. Industrial:		
1. Drying:		
linseed	warm, cool	moderate
tung	warm	moderate, heavy
2. Waterproofing:		
cottonseed	warm, hot	moderate, heavy

The areas under each great oil crop are shown in fig. 7; the quantities produced or exported are shown in fig. 18.

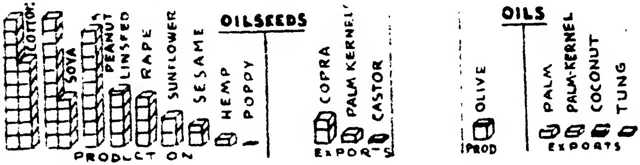


Fig. 18.—OILSEEDS AND OILS. One cube represents 1,000,000 metr. tons. No comparison can be made between the various parts of this diagram, which represents all our present statistical information.

Coconut oil is obtained from the nut of the coco palm[1], which yields many other valuable products, and mostly grows on wet hot shorelines. The oil may be produced where coco palms are grown, but often the dried pulp of the nut, called copra, is exported: the oil is then expressed from copra in the importing country. There is a small export trade in coconuts as well. The oil is used not only as an ingredient in edible compounds or soap, but also to make different ointments and other medicinal preparations.

Other edible oils from Wet Hot Regions include palm oil, and palm kernel oil, obtained from the fruits and the fruit kernels of the oil palm[2], growing only in West African Wet Hot Regions; and kapok oil produced only in Java from the seeds of the kapok tree[3].

Cottonseed oil is obtained wherever cotton[4] is grown; the main centres of seed production are Warm East-coast North America, wet (or irri-

1 *Cocos nucifera.*
2 *Elaeis guineensis;* the oil is rich in vitamin A.
3 *Ceiba pentandra.*
4 *Gossypium sp. v.*

gated) parts of India, and sufficiently warm, wet or irrigated parts of the Soviet Union and China. Much oil is produced by countries which find it cheaper to import the seed and to treat it locally. A great quantity of cottonseed oil is used in making margarine, soap, and in the canning of fish.

Peanut oil is used for the same purposes as cottonseed oil, with the great advantage that it is edible without any special treatment. It is extracted from peanuts[5] grown in most Savanna Regions, and in Warm East-coast Regions, particularly in India and China (map 32). Many countries prefer to import peanuts (with or without shell) in order to extract the oil locally.

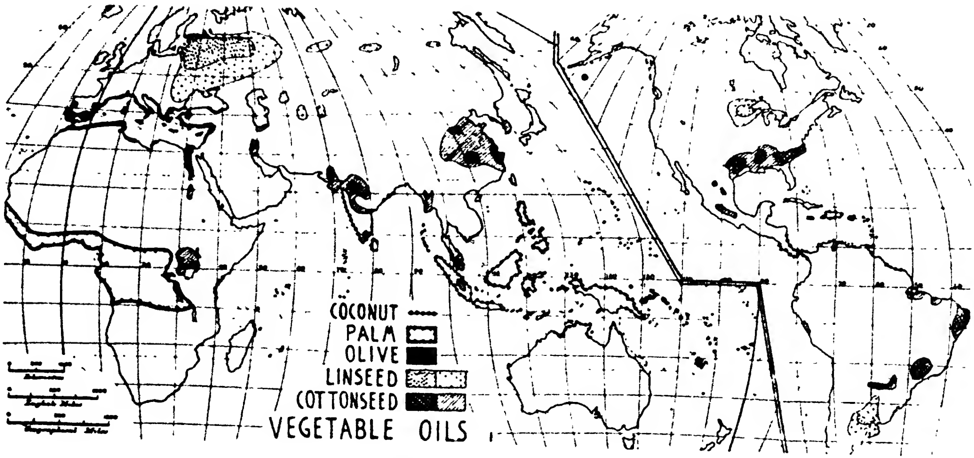
Olive oil is the only fat substance used by many people around the Mediterranean, and is largely used also for the canning of fish; it is obtained by pressing the fruits of the olive tree[6] (map 30).

Other edible oils from temperate countries are maize oil, produced only in North America; tea oil which is produced almost exclusively in China, from a tree[7] allied to the tea shrub; and linseed oil which becomes edible only after special treatment, and is generally used for other purposes (maps 23 and 30).

Soya-bean oil is the most important fat produced in the mildly cold and cold countries of Eastern Asia; now it is produced also in the corresponding regions of North America (map 31).

Other edible oils from cold countries are obtained in the Soviet Union from hempseed, rapeseed, linseed, and sunflower[8] seed; hempseed oil

5 *Arachis hypogaea.*
6 *Olea europaea;* the var. *sativa* (*fragrans* according to other authors) is cultivated.
7 *Thea sasanqua.*
8 *Helianthus annuus.*



Map 30.—VEGETABLE OILS 1. The areas under flax and cotton can be found on map 33 with the exception of the Argentine linseed plantations where no fibre is produced. The limits of the oil palm and the coconut palm are shown—oils are actually obtained from smaller areas. The map shows how olive oil is produced only around the Mediterranean.

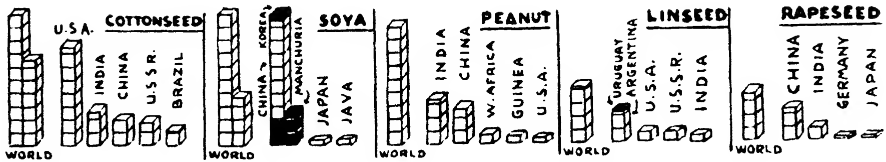


Fig. 19.—OILSEEDS. One cube represents 1,000,000 metr. tons.

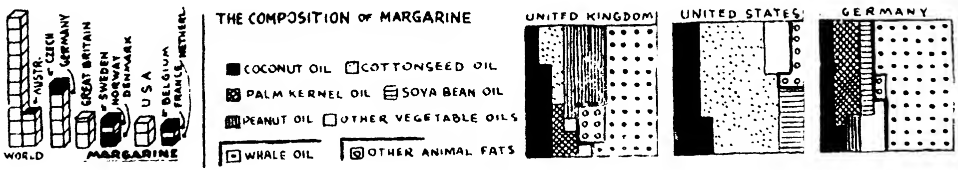
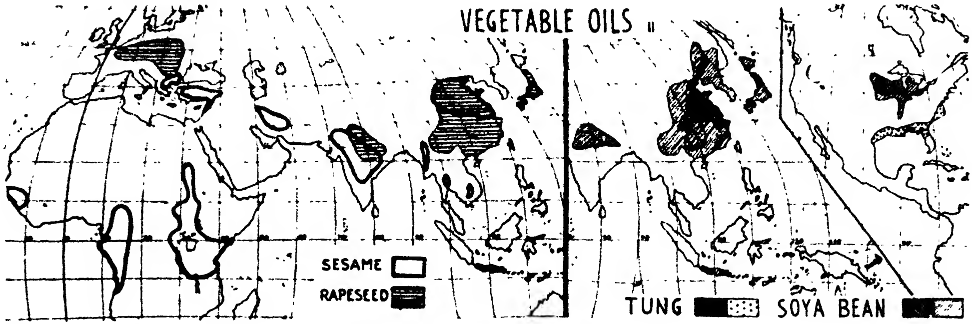
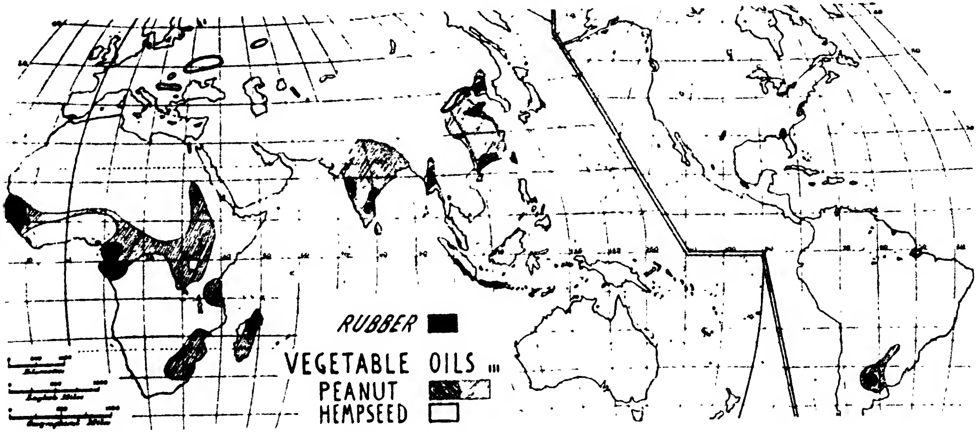


Fig. 20.—MARGARINE. One cube represents 100,000 metr. tons. The squares show how the composition of margarine varies from one country to another; note how whaling contributed to solve the German fat shortage. A large square represents 100 per cent.; a small square as shown in the key represents 1 per cent.



Map 31.—VEGETABLE OILS II. This map shows once more how India and China are the meeting place of the most different crops. Note the extent to which soya bean and tung tree cultivation has spread in the United States.



Map. 32.—VEGETABLE OILS III.—RUBBER. Four types of rubber districts are shown: the wild rubber areas of the Amazon; the wild rubber and small plantation areas of West Africa; the very small but extremely important plantation areas of Malaya and the Malay Archipelago; and the new dandelion plantations of Soviet Asia.

is also largely produced in Northern China and Manchuria (maps 30, 31, 32 and figs. 18 and 19).

The main groups of industrial oils and fats include those which dry easily, those which lubricate to reduce friction, and those which impregnate a surface and make it waterproof.

Linseed oil is the most widely used oil for paint making, because it dries easily; it is one of the main constituents of linoleum. It is obtained from flax seed (map 30, and fig. 19).

Other drying oils which are very valuable for paints are tung oil which is obtained from the fruit of a small tree[9] growing mainly in warm east-coast China, now introduced in North America (map 31); perilla oil produced from seeds[10] grown in Manchuria; soya-bean oil; maize oil, poppyseed oil obtained mainly in mildly cold Europe.

Although most lubricants are of mineral origin, castor oil[11] is considered one of the best lubricants for high speed engines. Olive oil and rapeseed oil are also good lubricants.

Waterproof oils include first cotton oil, and in certain applications boiled linseed oil; others are maize oil, kapok oil.

Other important industrial applications of some oils mentioned above are leather dressing (maize, peanut, castor oils); patent leather (linseed oil); printing inks (linseed, perilla, soya-bean oils).

Cotton goods are generally treated with palm oil at the mills; palm oil is used at a certain stage in tinplate making. Eucalyptus oil[12] is used in

9 *Aleurites fordii.*
10 *Perilla ocymoides.*
11 *Ricinus communis.*
12 Chiefly distilled from the leaves of the blue gum (*Eucalyptus globulus*).

extracting some metals from their ores. Glycerine may be obtained from linseed oil or soya-bean oil. Australian eucalyptus oil and sandalwood oil[13] are valuable in medicine. Lemon oil, almond oil, and rose oil[14] (attar of roses) are used in medicines and cosmetics. Camphor oil is used by the chemical industry; it comes from South-Eastern Asia[15] (although much camphor is now obtained from European and American turpentine).

13 From the wood of *Santalum spicatum* in Western Australia, of *S. album* in the Malay Archipelago and the dry southern Indian areas.

14 From the petals of cultivated rose varieties, which derive from the several wild species of *Rosa*; see "A Book of Roses" (Penguin Books).

15 By distillation of the wood and leaves of *Cinnamomum camphora*.

VIII. VEGETABLE FIBRES.

From the point of view of quantity, cotton is by far the most important fibre grown as it is produced in larger quantity than all other vegetable fibres together. The production of cotton is about three times greater than that of wool, the main animal fibre, and twelve times greater than that of asbestos, the only mineral fibre.

There are several kinds of cotton plants, generally shrubs[1]. Most cotton fibre is yielded by a shrub which grows in the Indian Savanna Region, and two others which grow in the Warm East-coast and the Savanna Regions of North and Central America. The Indian plant[2] yields a short and wiry fibre and is of lesser importance. The American cotton commonly called upland cotton[3] yields a longer and softer fibre; the other kind of American cotton is even longer and softer, and is known as sea-island cotton[4]. Unfortunately it is rather exacting as to climatic conditions, and is easily attacked by diseases and parasites.

In all these cotton plants the fibre is formed in the pod, together with the seed; in sea-island cotton the seed does not stick to the fibre. In all other species of cotton, the fibre has to be torn from the seed, a process which is called ginning.

1 According to some botanists there are only three species of cotton plants; according to others there are well over fifty. Two species are trees: *Gossypium arboreum* which is sometimes cultivated in southern Asia and north-eastern Africa, and *G. brasiliense* (kidney cotton) sometimes cultivated in Brazil and Peru. Several tree varieties known as *caravonica* have been obtained in Queensland by crossing various species. Shrubs which yield a yellow-brown fibre are *G. nanking* and *G. obtusifolium*, still grown in eastern Asia where the better species have not been introduced. *G. peruvianum* is perhaps one of the species which gave rise to the better Egyptian cottons (*sakellaridis*), which are hybrids.

2 *Gossypium herbaceum*; the wild species is *G. stocksii*.

3 *G. hirsutum*.

4 *G. barbadense*.

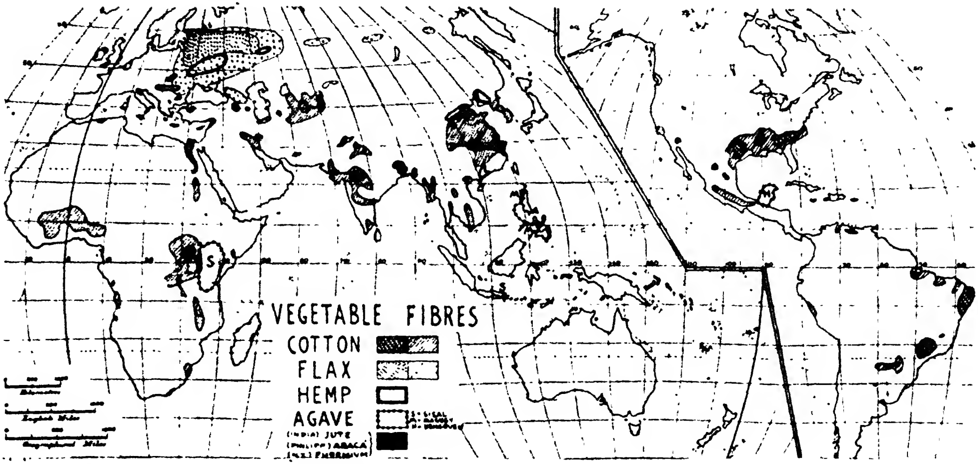
A list of vegetable fibres (map 33, figs. 21 and 22).

Fibres	Climatic Requirements	
	Temperature	Rainfall
A. Textile:		
cotton	warm, hot	moderate, heavy
(rayon)	—	—
flax	warm, cool	moderate
hemp	cool, cold	moderate
B. Bag and cordage:		
jute	hot	heavy
abaca	hot	heavy
sisal	hot	low
phormium	cool, oceanic	moderate
coir	hot	heavy
C. Stuffing:		
kapok	hot	heavy

Picking is done by hand, ginning by machine; the seed is valuable for its content, which is extracted; the residual by-product is used as stock feed. Linters (cotton waste) are the very short fibres which are left after the good fibres have been removed; they are the raw material from which cellulose is obtained, and celanese rayon fibres are made.

Upland cotton can grow only where there are at least 200 days without frost, and water is available during the growing period. Later on, rain would damage the pods while they are being formed. The great cotton-growing lands are Warm East-coast North America, the drier parts of India, Turkestan and Lower Egypt (where water is supplied by irrigation), China and Brazil.

Cotton fibres are carded to obtain a long untwisted thread-like line, which is then spun to form a thread; this thread can be woven. Cotton manufacturing is extremely important on both



Map 33.—VEGETABLE FIBRES. Flax production is relatively unimportant in the southern districts of the area shown above. The cotton districts where irrigation must be practised should be identified on a rainfall map. The cotton plantations of Queensland are too small to appear on this map. Note the distribution of the two fibre plants in the Philippines.

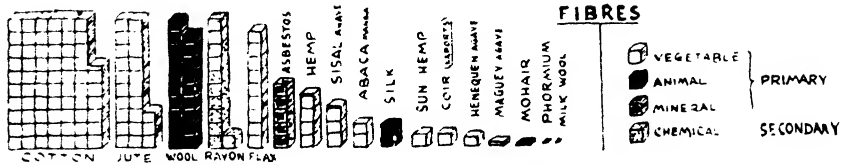
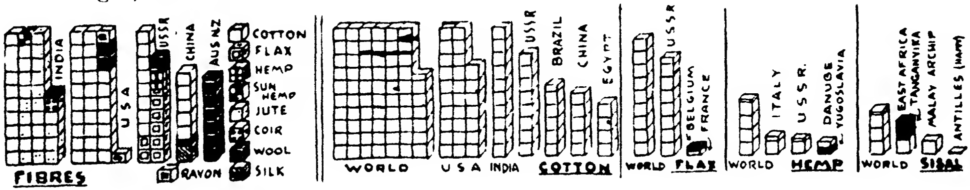


Fig. 21.—FIBRES. One cube represents 100,000 metr. tons. Rayon is actually of vegetable origin, but—as a fibre—it is man made.



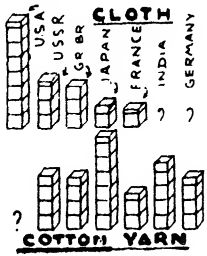


FIG. 22.—THE GREAT FIBRE PRODUCERS — VEGETABLE FIBRES—COTTON YARN AND CLOTH. One cube represents 100,000,000 metr. tons of fibre or yarn, or 1,000,000 square metres of cloth. Note the importance of the U.S.A. as a cotton producer, the rapidly growing production of the U.S.S.R., and the relative disproportion between cotton-yarn and cotton-cloth production in Japan, due to the fact that rayon staple fibre and cotton yarn were used together in the production of cloth.

sides of the Atlantic; the greatest production is in the eastern United States, especially in the north-eastern areas, around Boston. Next comes the U.S.S.R. (Tashkent, Ferghana) and then England (Lancashire), Central Europe, Japan (Osaka), India (Bombay), and China (fig. 22).

Rayon is the second most important vegetable fibre used for clothing purposes. Since the raw material from which rayon is mainly produced is a forest product, it will be discussed when dealing with timber and its allied products.

Flax is a very strong fibre obtained from the bast of the flax plant[5] from the seed of which linseed oil is extracted. The best fibre is obtained from plants which have not ripened their seed; for this reason oil production is not very great in fibre-producing countries. This is even more so now, because special oil-bearing varieties have been evolved, which would give a rather poor fibre.

The flax plant is uprooted, rippled (combed) to get rid of seeds, and retted, that is, laid in water or steam to rot; open air dew-retting is also practised. Then it is crushed, and the useless parts are discarded, leaving the fibres. All these operations are still performed by hand in most flax-growing areas, but in Australia modern machinery has been devised, by which flax fibre (or, as it is also called, linen fibre) may be produced cheaply. Flax fibre is much stronger than cotton and has a superior whiteness.

The mildly cold areas of the Soviet Union are by far the most important flax fibre producers.

"Hemp" is a name which is carelessly given to

5 *Linum usitatissimum.*

several fibres. True hemp is the fibre of the hemp plant[6], a very tall annual, the fibre of which is extracted in the same way as flax fibre. It is grown in some mildly cold countries of Europe, mainly in Russia, Northern Italy, and the Danubian Basin (map 33).

Hemp fibres are longer and coarser than linen fibres, and are much used in the making of strong tissues such as are needed for sails, tarpaulins and special bags, or ropes and strings; the finer fibres are used in the making of household linen.

The production of sun hemp[7], grown in India, is slightly less than Italian hemp production; the fibre is very coarse and used locally (figs. 21 and 22).

There are two species of giant nettle known as ramié[8] and grown for their fibre in China, Eastern India, Malaya and Java. The fibre is unshrinkable and extremely tough, but some technical difficulties prevent its widespread utilisation; it is used in the making of ropes, nets, incandescent gas mantles and special tough paper such as used in banknotes.

Jute fibre is obtained from the bast of very tall annual plants[9] which grow only on the river flats of Bengal (map 33). It is very coarse, and is mainly used to make sacks, bags and ropes.

The common name of a plant[10] related to the banana, and its fibre, is "manilla." In the Philippine Islands, which are the only "manilla" producing country, both plant and fibres are called

6 *Cannabis sativa.*
7 *Crotalaria juncea:* Deccani or gambo hemp (*Hibiscus cannabinus*) is less important.
8 *Boehmeria nivea* in China, *Boehmeria tenacissima* farther south.
9 *Corchorus capsularis* and *C. olitorius.*
10 *Musa textilis.*

abacá. The fibre is extremely tough and used to make ropes and twines.

There are three kinds of agave whose fibres are used to make ropes and twines; the main one, sisal,[11] grows wild in Mexico and is now cultivated in East Africa and Java (map 33). Henequen[12] (*heneken*) is grown in Yucatan; the third species is known in the Philippines as maguey[13] (*mag-ei*) and in Java as cantala (a name applied to sisal as well). These fibres are loosely called "hemp" and much confusion has resulted.

Coir is another product of the coco palm; it is obtained from the fibres enveloping the nut, and when fine is used for matting and rope-making, when wiry for brush-making. A curly and soft variety is used to stuff mattresses, and very soft coir may be woven. The main exporting centres are Southern India and Ceylon.

Kapok is the fibre attached to the seeds of a tall tree[14] growing in the Malay Archipelago; seeds and fibres are contained in a large nut. The fibre is too brittle to be woven, but is widely used in mattresses and upholsterings. Because of its buoyancy it is used in life-saving devices.

Similar fibres called silk-cotton are obtained from trees which grow wild in the savanna regions of India[15] and Brazil[16].

The very strong fibre known as "New Zealand flax"—or "hemp"—is obtained from the leaves of a hardy agave-like plant called phormium[17], which grows in New Zealand. It has been introduced into St. Helena, but since the decline of

11 *Agave sisalana.*
12 *A. rigida var. fourcroydes.*
13 *A. cantula.*
14 *Ceiba pentandra.*
15 *Bombax malabaricum.*
16 *B. ceiba.*
17 *Phormium tenax.*

sailing ships it has lost much of its importance.

In most rainy hot islands of the Pacific and Indian Oceans a pandanus palm[18] yields a rough fibre. In Europe sometimes fibres of the common nettle[19] are used to make sacks and bags. In Brazil a palm[20] yields a coir-like fibre, known as piassava. Raphia[21] fibres are used in gardening and basket-making. Rattan[22] stems are used for "cane" furniture and baskets.

All newsprint and most other paper is manufactured from fibres obtained from wood and will therefore be dealt with as forest products. Much fine paper is made from rags, which are selected, pulped and bleached; linen rags are considered best. Wrapping paper is often made from mixed fibres, or from straw. Much so-called "rice paper" is obtained from a small tree[23] related to the mulberry, which grows especially in Formosa. Many books are printed on "esparto" paper; the correct name is actually alfa[24]. The plant is like a very coarse grass, growing on the semi-dry Algerian plateau. Large quantities are exported and pulped to make paper.

Alfa leaves are so strong that they are locally used to make ropes and mats. Other plants are exported under the name of "esparto"[25]. Their fibres are generally less tough than alfa fibres.

18 *Pandanus odoratissimus*, best known as "screw pine"; the fibre is called vacua or vicua.
19 *Urtica dioica*.
20 *Attalea funifera*.
21 Several small palms belonging to the genus *Raphia*.
22 *Calamus rotang*, a climbing palm.
23 *Broussonetia papyrifera*.
24 *Stipa tenacissima*.
25 For instance *Lygeum spartum*.

IX. FOREST PRODUCTS.

The first step in the assessment of timber resources is to compare the areas covered by forests in the different Regions of the World. This shows that the widest continuous forest area covers most of the Cold Regions of Eurasia from the Atlantic to the Pacific. The second largest area is in a completely different Region, the Equatorial Forest basins of the Orinoco and the Amazon. The third area is much less compact and continuous, covering most of northern North America, but thinning out very much in the drier central lands, and thrusting south two arms covering the slopes of the Rocky Mountains and the Cascade Range to the west, and part of the Appalachians to the east. Much smaller areas are covered by forests in Equatorial Regions, such as the Congo Basin, and the Malay Archipelago and New Guinea (map 34, p. 166).

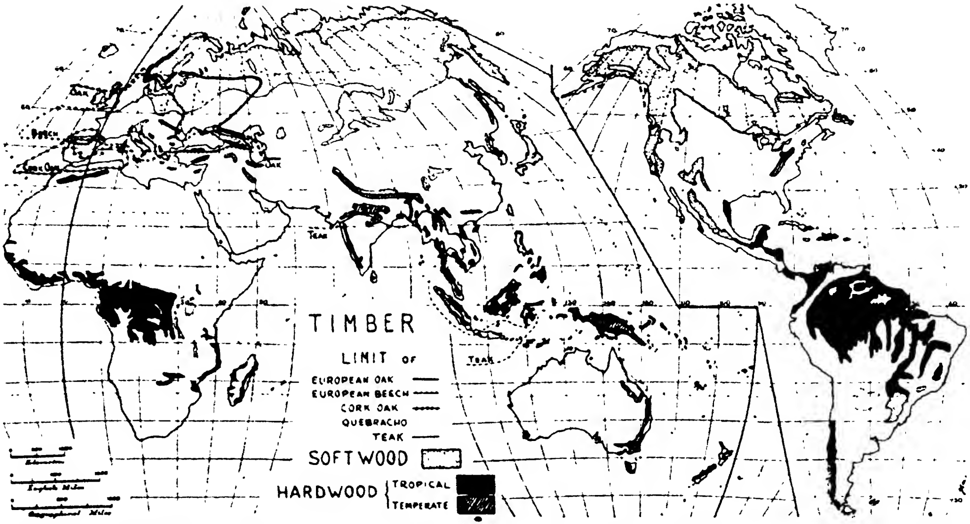
A comparison between forest areas of Europe, North America, and China, shows how agricultural development has meant the destruction of the forest in all the old agricultural countries of the World. China has lost most of its forests, except in the most inaccessible inner districts. Europe has lost most of its forests, except in those Regions where it was too cold for agricultural settlement, or where agricultural expansion has been very slow. In both China and Europe forest destruction has been slow and mostly forced upon man by his need for more arable land. The relatively short history of North America records such rapid forest destruction, that it will now take years of thorough research and planning to

establish the foundations of future reforestation, and to conserve forest resources. The very slow growth of trees makes tree plantations a task unattractive to private enterprise looking only for immediate profit.

It is not enough to have extensive forests, it is necessary to be able to reach the trees to be cut down, and to be able to carry the logs to where they will be used. This explains why most equatorial forests have not been exploited as yet. They grow in Regions where hard work is extremely difficult, where animal power can hardly be used because of the climate, where there are no roads, so that mechanical power cannot be used either. Were the trees cut down, the logs could not be transported by land, and it might even be impossible to float them down the rivers because some equatorial timbers are heavy hardwoods.

It is much easier to do heavy work in cold climates than in hot climates. Land transport is simplified by the fact that in most cold Regions there is little or no undergrowth, so that the felled log can be carried or dragged along without great difficulties. Timber grown in a very cold climate is generally much lighter than timber grown in a hot climate; it can easily be floated wherever there are suitable streams. When the ground is covered with frozen snow, an ideally smooth surface is secured over which sledges can carry heavy loads.

From the technical point of view, timbers are classified as hardwoods and softwoods (map 34). There are timbers of intermediate hardness but generally the two groups are fairly distinct. As a rule, conifers such as pines and firs (called also



Map 34.—TIMBER. Limits are shown by continuous lines, broken over water expanses. There are other oak and beech trees outside Europe, which are not shown above. European softwood forests have been greatly reduced. Note the small area of softwood forest on the Alps, and the two southward prongs along the Rocky Mountains and the Cascade Range. Note also the softwood forests of Southern Brazil. Tropical forests produce softwoods as well.

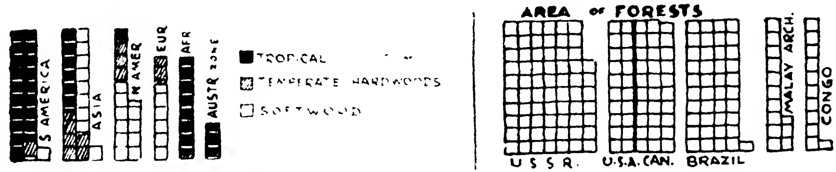


Fig. 23.—TIMBER. One square represents 40,000,000 hectares of forest in the diagram to the left, 10,000,000 hectares in the one to the right. In the assessment of timber values from the geographical point of view, it may be assumed that rainy lands produce quickly-growing trees, whose fibres are long and whose timber is soft. Trees growing in dry or even seasonally dry lands tend to have shorter fibres and harder (more compact) timber. Temperate hardwoods such as beech and oak are an exception to this rule.

needle-leaf trees) yield softwood, and broadleaf trees such as oaks or eucalypts yield hardwood.

Some conifers, as the Australian cypress pines[1], yield a rather hard timber; some broadleaf trees yield a soft timber, as poplars, birches and willows.[2] Usually dry climates produce hard timbers and rainy climates produce soft timbers.

Conifers form forests with little undergrowth and with very few species, sometimes even only one species. Broadleaf trees in mildly cold countries are sometimes mixed with conifers; they belong to few species, and the undergrowth is not excessive. In Warm East-coast Regions forests are dense, there are numerous tree species, and the undergrowth is often luxuriant. In equatorial forests there are many species of trees, and the undergrowth is itself a forest.

Dry conditions such as prevail in summer in Temperate West-coast Regions, or in winter in all Savanna Regions, make tree growth very slow, and timbers are often uneven in grain and therefore of less value. Excessive cold and waterlogged soil have much the same effect, and the northern margin of Eurasian and North American forests is mainly formed by trees yielding a timber whose grain is not straight and regular, and which may therefore be used only for rough work, or to provide woodpulp.

Great destruction has been wrought in forested areas, first by obtaining timber for buildings, ships, furniture, and for firewood, besides the ever-increasing clearing to obtain agricultural land. But the greatest destruction within a rela-

1 *Callitris sp. v.*
2 *Populus, Betula, Salix* respectively, with many species.

tively very short time took place since the invention of the railway. The need for sleepers led to great inroads into the remnant of European mixed forests, and to the deforestation of whole districts in North America; hardwoods particularly were sought for the purpose. A little later came the great demand for woodpulp; the wonderful development of the Press during the last century has meant spoliation of those softwood forests which had been spared by sleeper-cutters. These two sources of demand for hardwoods and softwoods respectively have caused more damage in a century than agricultural expansion had caused in thousands of years.

The laying bare of whole mountain slopes has increased surface drainage and the speed of torrents and rivers. The speed of running water, unchecked by vegetation, washes off much soil. Whole hill and mountain districts become bare and barren. Plains which were once covered by vegetation are now exposed to all winds after they have been cleared. Soil erosion plays havoc.

Human activity now turns from destructive exploitation to conservative planning. During recent years scientific research has been applied to forest restoration, or reforestation; sometimes new forests are planted (afforestation). Saplings are planted, hillsides are consolidated, steep slopes are interrupted by special works. Reforestation and afforestation are hardly matters for private enterprise; forest destruction threatens the whole community, and the whole community is therefore concerned. Wherever existing forests are endangered by ruthless exploitation, public initiative steps in and only those trees are cut

down which experts mark for the purpose. Natural growth is encouraged, and carefully-selected saplings are raised. Where natural growth is slow or lacking, supplementary new saplings are planted. If foreign trees are more valuable than native ones, experiments and trials of varieties are carried out and the whole landscape is sometimes changed by extensive plantings of trees never seen there before. Thus in Australia, where softwoods are scarce, American and European pines have been planted in many localities.

The greatest timber wealth in Europe and Asia belongs to the Soviet Union, and consists mainly of conifers, such as spruce[3], pine[4], larch[5] and fir[6].

Russian hardwood is obtained from oak and beech trees, the former represented by one species[7] in Europe and by other species in the Far East, the latter[8] in the Ukraine only (map 34), but hardwood production is extremely small compared with softwood production, which is very great.

In North America, the enormous development of railways and printing led to great forest destruction in the United States first, and then in Canada. The timber industry, which was centred on the Eastern States, through depletion of most of its supply had to move west. At present over three-quarters of the United States timber output comes from coniferous forests of the Cool West-coast Region and its mountain ranges; one-third

3 *Picea excelsa* in Europe. *P. obovata* in Siberia. *P. ajanensis* in the Far East.
4 *Pinus silvestris*, the Scots pine.
5 *Larix europaea*.
6 Genus *Abies*; the silver fir is *A. alba*.
7 *Quercus robur*.
8 *Fagus silvatica*.

of Canada's timber comes from the west. In both countries Douglas fir[9] is by far the most important species, followed by other conifers, such as pines[10], spruces[11] and cedars[12].

Some species of pines[13], spruces[14] and cedars[15] are represented in the eastern forests, where the most valuable species is the hemlock spruce[16], also a conifer, yielding large quantities of tannin. Hardwoods are better represented in what is left of these eastern forests, where various oaks[17], beeches[18], maples[19] and elms[20] are found (maps 28 and 34).

Several countries grow timbers which are extremely valuable for certain purposes, and give rise to an extensive trade even when produced in relatively small quantities. From the practical point of view, they may be divided into cabinet woods and structural timbers. The most important cabinet woods are mahogany[21] (a name which is applied to many red timbers from equatorial and tropical forests), ebony (which is obtained from several trees yielding a black or almost black timber, the best one[22] coming from

9 *Pseudotsuga mucronata*, the source of most "oregon" timber.
10 *Pinus murrayana* (black pine); *P. albicaulis* (whitebark pine); the western yellow pine (*P. ponderosa*) grows in the semi-arid western lands.
11 *Picea sitkensis* and *P. engelmanni*.
12 *Thuja plicata* (western red cedar) and *Chamaecyparis nootkatensis* (yellow cedar).
13 *Pinus strobus* (white pine); *P. banksiana*.
14 *Picea canadensis* (white spruce); *P. mariana* (black spruce); *P. rubra* (red spruce).
15 *Thuja occidentalis* (white cedar).
16 *Tsuga canadensis*.
17 *Quercus alba* (white oak) and other species.
18 *Fagus grandifolia*.
19 *Acer saccharinum* (sugar maple), *A. rubrum* (red maple) and other species.
20 *Ulmus racemosa* (cork elm); *U. fulva* (slippery elm); *U. americana* (American elm).
21 True mahogany is *Swietenia mahogani* of the Antilles and Central America.
22 *Diospyros ebenum*.

the Indian savanna), and cedar[23] (a name applied to many scented rather light woods, some of them growing in tropical forests). There are, however, hundreds of beautiful tropical cabinet woods; most of them are now used in very thin layers called veneers, covering ordinary timber.

Structural timbers may be used for many purposes. Teak[24] from the equatorial forests of south-eastern Asia (map 34) is most important for shipbuilding and jetties because it repels wood-boring animals; jarrah[25] from south-western Australia is excellent for paving blocks and railway sleepers; karri[26] from the same Region makes good sleepers if treated with a preservative. Oak and beech are still a main source of sleepers in Europe (map 34), but large quantities of jarrah are imported. Whenever it is not indispensable to use hardwood, any of the softwoods mentioned above are used, and they are even preferred when light structures have to be built.

Softwoods are used to make plywood, in which several layers of wood are superimposed crosswise. Plywood is used for light structures. For extremely light works, such as airplane models and wooden airplane parts, balsa[27] wood is used; it is an exceedingly light timber obtained from the equatorial forests growing on the slopes of the Andes.

In countries where termites are a menace, there

23 The cedar of the Lebanon (*Cedrus libani*) is almost extinct. The stately Himalayan cedar (*C. deodara*) yields a useful timber. Cedar wood is obtained from *Cedrela odorata* of the Antilles, *C. toona* of Queensland. Cedar pencils are generally made of juniper wood. The most important veneer wood from temperate climates is obtained from the walnut tree (*Juglans regia*) which grows from Western Europe to the Himalaya.

24 *Tectona grandis*.

25 *Eucalyptus marginata*.

26 *E. diversicolor*.

27 *Ochroma lagopus*.

is a keen demand for those timbers which repel insects because of their smell. Australia has the slender cypress pines[28] of the semi-arid Regions; the extremely hard raspberry jam[29] (a species of acacia) makes very durable termite-proof fence posts in south-western Australia.

Wood Products.

by sawing	timber
by burning	charcoal
by distilling	resin, pitch and wood-tar
by grinding	mechanical woodpulp
by dissolving	chemical woodpulp

Charcoal is made in varying quantities from hardwoods by burning them out of contact with the air; its importance had greatly decreased until gas-producers were designed and applied to internal combustion engines. When wood is cheap, charcoal is still an important fuel.

Pitch and wood-tar will be mentioned in the next chaper with other resins.

Most softwood is now taken straight from the forest to the mill, where it is sawn, ground, and transformed into woodpulp. This process yields what is known as mechanical pulp, which is used for ordinary paper, mainly newsprint. Finer paper is made of chemical pulp, which is obtained by dissolving the wood by chemical means.

The United States and Canada are by far the greatest woodpulp producers; Canadian mills produce more mechanical pulp, while most United States mills specialise in the more exacting chemical processes. Most European pulp production, which is mainly chemical, is centred near the edge of the great coniferous forests, from Norway to

28 *Callitris glauca. C. robusta.* and other species.
29 *Acacia acuminata.*

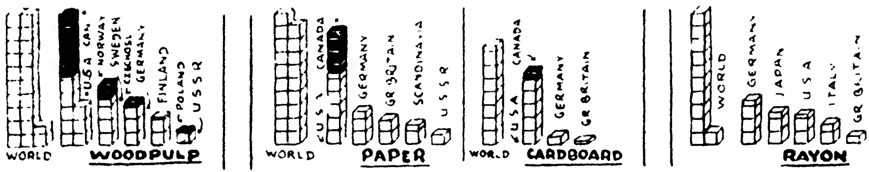


Fig. 24.—CELLULOSE PRODUCTS. One cube stands for 1,000,000 metr. tons of woodpulp, paper or cardboard, or for 100,000 metr. tons of rayon. Not all paper and rayon are made from woodpulp; some of the better papers are made from alfa or esparto fibres or from linen rags, whereas celanese rayon is made from cotton linters.

Russia; Germany has been able to develop an important pulping industry by working timber from the Alps and other sources.

Australia has been able to produce woodpulp from hardwood, which is obtained from a species of eucalypt[30] which grows in Tasmania and Gippsland.

The bulk of the World's paper is obtained from woodpulp, and North America alone accounts for little less than half the World's production. Germany and Great Britain follow, working largely on imported material; the northern European lands come next (fig. 24).

Most of the World's cardboard is produced in the United States.

Rayon is obtained from the cellulose which is contained in woodpulp, sometimes in other vegetable matter. The cellulose is dissolved until it becomes a jelly, which is forced through tiny holes, thus forming threads. There are various ways of working it.[31] The fibre may be produced to any length or thickness, and this is a distinct advantage over other fibres. Production is not affected by the location of timber resources, because either woodpulp or cellulose can easily be transported. The greatest producer is Germany, which works mainly on imported raw material, followed by Japan, in a somewhat similar situation. The United States and Italy come next

30 *Eucalyptus regnans.*

31 The viscose process is by far the most important, but small quantities of rayon are produced by the cuprammonium and the acetate processes. Statistics distinguish between rayon yarn, which is obtained in any length and is usually pure rayon, and staple fibre, which is a short rayon fibre cut to a suitable length to be spun with cotton or wool or any other fibre. Japan, Germany and Italy used to produce more staple fibre than rayon yarn in order to reduce their cotton and wool imports.

(fig. 24). This distribution shows that rayon is mainly produced where there is a shortage of other fibres, and at the same time chemical and mechanical industries are well developed.

The bark of an oak[32] growing in western Mediterranean lands constitutes cork, which is used for many purposes in several industries, although many substitutes have now been found (map 34).

Other forest products, such as tanning materials, are discussed in the next chapter.

32 *Quercus suber.*

X. OTHER VEGETABLE PRODUCTS.

Many gums and resins are obtained by making incisions in growing plants and collecting the fluid which oozes out. When the fluid dries a gum or resin is formed, according to its chemical properties. Resin is chiefly obtained by a secondary —chemical—industry, from North American softwoods; smaller amounts are produced in Eurasia. Pitch and wood-tar are produced mainly in Eurasia, and to a lesser extent in North America, by a simpler process.

Turpentine, from which camphor may be distilled, is obtained from several European and American pines.

Dammar is obtained from a large tree[1] of the Malay Archipelago, kauri gum is gum secreted by kauri pines[2] growing only over a small area of North Island in New Zealand and copal is obtained from several plant species[3] growing in Central America and Bengal; these are all valuable resins used in the making of fine varnishes. Lumps of kauri gum have been found buried in the ground, in a semi-fossilized condition; they are now increasingly rare. Amber is a semi-precious material which is a fossil resin[4]; it is found mainly around the Baltic.

A red resin called dragon's blood is obtained from several trees which grow in hot regions. Another resin used in varnish-making is the Mediterranean mastic, secreted by a shrub[5].

1 *Dammara orientalis.*
2 *D. australis.* Cedar gum is a similar product obtained from *Widdringtonia juniperoides*, the cape cedar.
3 *Protium copal. Bursera tomentosa* and other species of *Bursera* grow in Central America. *Canarium bengalense* grows in Bengal.
4 From the extinct coniferous *Pinites succinifer.*
5 *Pistacia terebinthus.*

Aromatic resins are less important now than they were in the past. Camphor is used in plastics and medicinals, but as a repellant is extensively replaced in the household by naphthalene of mineral origin. It is distilled mainly from a tree[6] growing in South-Eastern Asia, but much camphor is now obtained from turpentine.

Other aromatic resins, which are burned during religious ceremonies, are true frankincense[7] and myrrh[8] from various shrubs of the very dry areas of Arabia and Somaliland; and benzoe which is obtained from the stems of a plant[9] in Indo-China and the Malay Archipelago, and is used also for medicinal preparations.

Gum arabic, still widely used as an adhesive material, is obtained from many species of acacias[10] growing in the semi-dry and desert Regions of Africa, Arabia and Australia. It is also used to stiffen cloth prior to printing.

Gum tragacanth which is obtained from the semi-dry Region south of the Mediterranean and is the product of a small shrub[11], is used in a special process of cloth printing.

The main ingredient of chewing gum is chicle (*chi-kle*) obtained from a Mexican plant[12].

Carnauba[13] is the only vegetable wax of some value; it is found in Brazil and is used in the making of gramophone records because of its

6 *Cinnamomum camphora* (see end of Chapter VII).
7 *Boswellia carteri:* common frankincense is obtained by distillation from the silver fir (*Abies alba*).
8 *Balsamodendron murrha*.
9 *Styrax benzoin*.
10 *Acacia senegalensis* of the Sudan; *A. arabica* of the Sudan and Arabia; *A. gummifera* of the Sahara and Sudan; *A. horrida* of South Africa; *A. catechu* of India; *A. pycnantha* of Australia.
11 *Astragalus gummifer* and other species.
12 The sapodilla (*sapodilya*), *Sapota achras*.
13 *Copernicia cerifera*.

smoothness and great hardness. Vegetable dyes were very important before the invention of synthetic coal-derived dyes. Logwood[14], which grows in the tropical forests of Central America, is still exported in large quantities; it can dye purple, black or grey according to different treatments. Fustic[15], a wood obtained in the tropical forests of South America and the Antilles, dyes yellow or khaki. Gambir[16], obtained from India, dyes black or brown; it is a tannin-containing wood.

Indigo, a blue dye obtained in India from a small plant[17], is now used only locally. Other substances such as madder dyeing red, sumach (*sumak*) dyeing brown, turmeric dyeing yellow[18], have now been almost completely replaced by chemical products. Litmus[19] from the Canary Islands and tropical America and Africa is still used in chemical tests.

Although now much tanning is done with products of mineral origin, vegetable tanning substances are still very valuable. Many trees contain more or less tannin in their wood or their bark and large quantities are obtained in Europe from larch[20] bark, in North America from hemlock bark. Several kinds of oak contain a valuable tannin used for fine leathers in both Europe and North America. The wood of the chestnut tree is also used for the extraction of tannin.

Australia has many valuable species of tannin-

14 *Haematoxylon campechianum.*
15 *Maclura tinctoria.*
16 *Uncaria gambier.*
17 *Indigofera tinctoria.*
18 Madder or garancine = *Rubia cordifolia* of India *R. tinctorum* of Southern Europe, sumach = *Rhus coriaria*, turmeric = *Curcuma longa.*
19 It is extracted from various lichens, *Roccella tinctoria* being the chief species; acids change it from blue to red.
20 *Larix europaea.*

yielding plants, acacias[21] and eucalypts. One of the acacias, which also yields gum arabic, was introduced into South Africa, and now most exports come from there. Mallet[22], a small eucalypt, is now being replanted in the drier West-coast Region of south-western Australia, where it had been almost destroyed. Western Australian tannin is generally obtained from wandoo[23].

The most important tanning wood in international trade is now quebracho[24] (*kebracho*) growing in the Warm East-coast Region of South America (map 34); it contains so much tannin that the whole wood is sometimes used for quick, cheap tanning. Other tanning materials of more than local importance are the leaves of the sumach (*sumak*) and the wood of the gambir, already mentioned as dyes; the acorn cups of the valonia oak[25] of the semi-dry Mediterranean lands; the pods of the divi-divi[26] of South America; myrobalans[27] from India; gall nuts[28] obtained from China.

Gutta-percha is the coagulated latex of several trees[29] growing wild in the Malay Archipelago; it is used in relatively small quantities for very many purposes, mainly because, though less plastic than rubber, it can be melted and moulded easily.

21 *Acacia pycnantha*, *A. mollissima*, and other species.
22 *Eucalyptus astringens*.
23 *Eucalyptus redunca;* the name "white gum" should be avoided because there is a quite different white gum in South Australia.
24 *Aspidosperma quebracho*.
25 *Quercus aegilops*.
26 *Caesalpinia coriaria*.
27 Fruits of *Terminalia chebula* (black fruit) and *T. belerica* (downy greyish fruit). Indian tanners use avaram or turwar bark (*Cassia auriculata*).
28 Produced on the leaves of various plants by the attack of tiny wasps.
29 *Dichopsis gutta*, *Payena leerii;* from the Guianas comes the latex of *Mimusops balata*.

Rubber has become extremely important only after the widespread adoption of motor vehicles.

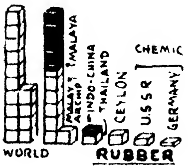


Fig. 25.—RUBBER. For the first time chemically produced rubber appears in statistics side by side with vegetable rubber. It is not known how much rubber is produced in the U.S.S.R. from kok-sagyz. "Wild" rubber is now practically negligible. One cube represents 100,000 metr. tons. Wartime synthetic output—still a secret—is certainly much larger.

Originally it was obtained from a kind of fig tree[30] growing in India and south-eastern Asia; then it was discovered in the hevea tree[31] of the Amazon forest, which became the main source of rubber for a while. Other plants[32] were found to yield more or less valuable rubber. When the demand grew beyond the supply possibilities of wild plants, plantations of hevea were established in Malaya and Java, where labour was more readily available, and within a few years most of the World's supply of raw rubber came from that source. Chemical research led to the discovery of suitable methods of obtaining rubber from alcohol, from benzol, or from petroleum. Two plants growing in temperate countries were found to contain rubber in payable quantities: guayule[33] (*gw-ayule*) of semi-dry Mexico, and kok-sagyz[34] (*koksagis*) a dandelion of the semi-

30 *Ficus elastica.*
31 *Hevea brasiliensis;* in Brazil it is called Pará rubber.
32 In Central America and northern South America an inferior rubber is obtained from *Castilloa elastica*. In Africa some rubber is obtained from species of climbing *Landolphia* and in West Africa from *Funtumia elastica*. In the Malay Archipelago *Urceola elastica* has been found to yield rubber.
33 *Parthenium argentatum.*
34 *Taraxacum koksaghyz.*

dry Turkestan. Rubber therefore is now obtained from several sources of varying importance and location[35] (map 32).

The very hard fruits of a small African palm[36] yield vegetable ivory which is used in the making of small articles, mainly buttons.

It has been mentioned that a mould is grown for the purpose of producing penicillin; two other species of mould are of economic importance because they are artificially induced in certain types of cream cheese.[37]

Some seaweeds are used in the making of gelatine or agar-agar[38].

35 A lesser rubber plant of hot climates is a small manioc tree. *Manihot glaziovii*, of the Brazilian savanna, which yields ceará (*se-ara*) rubber. In warm and hot Queensland a wild vine has been found to contain rubber; experiments are being made with many other plants.

36 *Phytelephas macrocarpa*.

37 *Penicillium roqueforti* is the species used in the making of Gorgonzola, Stilton and Roquefort cheese; *P. camemberti* is used in the making of Camembert cheese.

38 The chief supply comes from the red alga known as Ceylon moss, *Gracilaria lichenoides*. The finished product is known as agar-agar, and is largely used as human food in Eastern Asia.
In countries of western civilisation, seaweed jelly is used in meat canning; *Gracilaria confervoides* from Eastern Australia and *Eucheuma speciosum* and *E. gelatinae* from Western Australia are now processed in large quantities.

XI. MEAT.

Hunters obtain their meat from game. Herders raise animals to get supplies of meat and other products. Cultivators raise animals to obtain supplies of meat, other products, and power. Meat is still important, but is no longer the only product for which animals are kept.

The World's meat supply comes from three sources according to the type of industry concerned (map 18). The first source is hunting, and is still prominent in most forested lands, where there are no pastures on which domesticated animals can be raised.

The second source is nomadic herding, which prevails wherever there is no forest, and pastures are so poor that, as soon as the animals have eaten the available food they must be moved on to new grounds. This type of occupation is the only one possible in all the dry Regions of the World, except where water is available. The nomadic life does not allow of stock selection and of breeding only from the best types, and the standard of wandering herds is generally poor. The rather dry land has few springs and wells with potable water, and man must rely mainly on milk to drink. The only fibres available to the herdsman are animal hair or wool. Both milk and fibre are so important that the production of meat is no longer the main reason why animals are raised. In modern times a new semi-nomadic herding has been developed, what in Australia is called the station; in North America it is called ranch, in Latin America estancia (*estanthia*).

On the station, animals wander within wide

limits; they move on from pasture to pasture, and are mustered from time to time in order to be branded, inspected or sold—or to be shorn when wool is the main product of the station. The true nomad must always keep his animals herded together, because there are no boundaries or fences; the semi-nomad stockman relies — partly — on fences.

The methods followed on a station are intermediate between nomadic herding and settled animal raising, which is the third and most important source of the World's meat supply. The main feature of this type of animal raising is its reliance on stocks of fodder during at least part of the year. Animals may wander during the favourable period, when good pastures are available, but a time comes when they must be fed from stored supplies. Where the land is closely settled, such as in Europe, no ground is available for grazing, and animals are kept in stables the whole year round. Two interesting examples are afforded by North America and Queensland. In North America cattle pastured almost nomadically on the poorest grasslands east of the Rocky Mountains are sent to the maize districts (map 23) to be fattened prior to slaughtering. In Queensland some of the cattle raised on the poor vegetation of the interior are sent east of the Great Dividing Range to be fattened in the eastern coastal belt, where sugar by-products and maize are available.

It is not possible to mention all game animals; the quantity of meat thus obtained is so small that it may well be overlooked. Perhaps the most ancient meat-yielding animal is the sheep[1], easily

[1] *Ovis aries.*

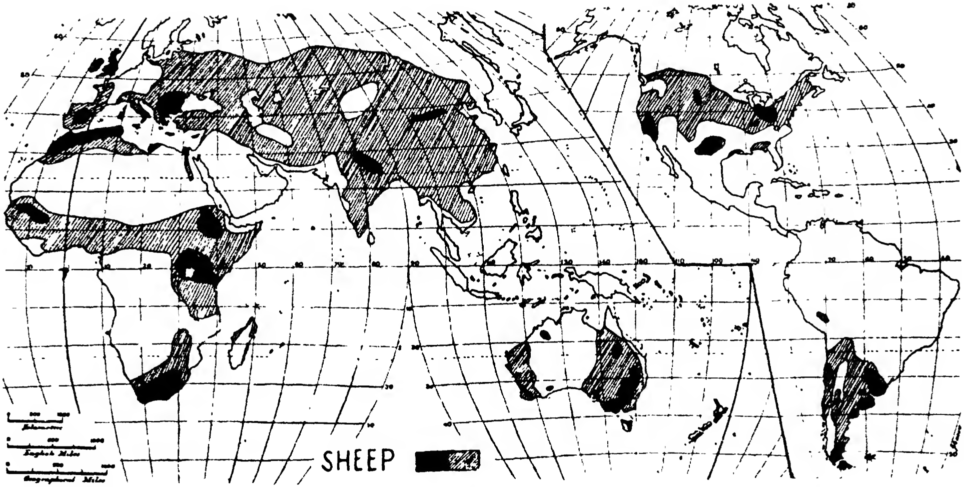
herded together, and with no defensive weapons. The quantity of meat yielded by a common sheep is rather small, and a long time elapsed before heavy sheep breeds were evolved. In most primitive herding communities, such as Arabs, Mongols and Sudanese, goats[2] are raised together with sheep, because they yield more milk; both the sheep and goats of these peoples are of a very poor standard. A heavy meat production is associated with good pastures, and no good mutton breed was developed until shepherding was introduced into Western Europe, and more particularly England. Careful selection and breeding led to a differentiation between wool breeds and mutton breeds, the former thriving on lighter pastures and drier ground, the latter preferring rich grass and Cool West-coast climate. British mutton breeds were introduced into similar climatic Regions, such as New Zealand, south-eastern and south-western Australia, Tasmania, parts of Argentina and Chile; these countries have now become the chief mutton producers of the World. Lamb raising is possible even in drier countries, provided suitable breeds are used, and enough suitable fodder is grown.

The best mutton breeds are the Shropshire, the Southdown, and the Dorset Horn; many other breeds are partly derived from these three.

Cattle belong to several species, with well-defined climatic requirements.

The enormous number of cattle living in India has little economic value, because meat consumption is forbidden to Hindus by their religion, and Moslems are not great meat eaters. Almost every-

2 *Capra hircus.*



Map 35.—SHEEP. The difference between major areas (black) and minor areas (shaded) is only relative, and fig. 28 should be consulted. Compare also with map 18.

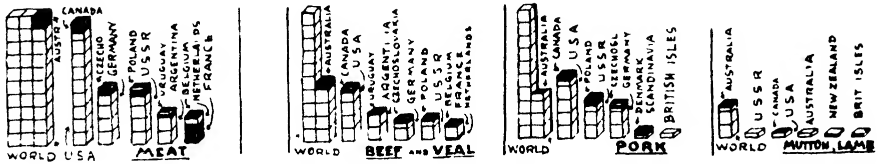
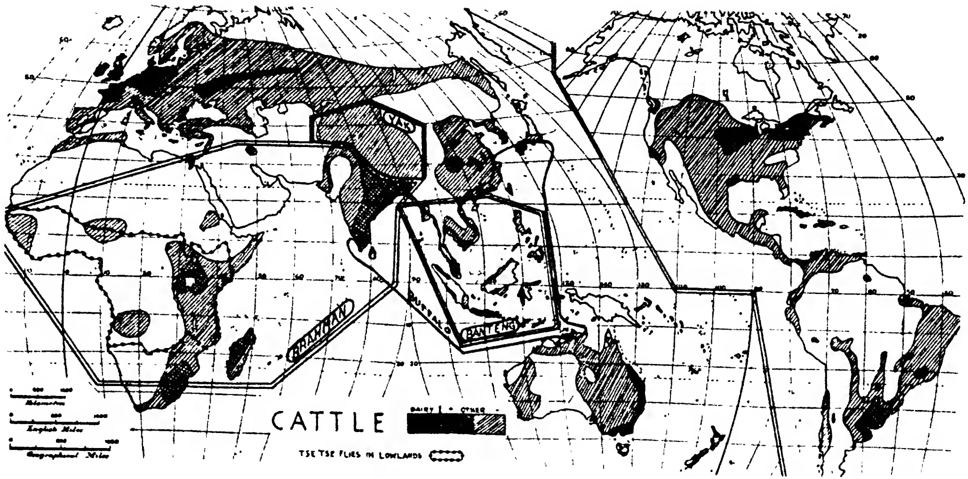
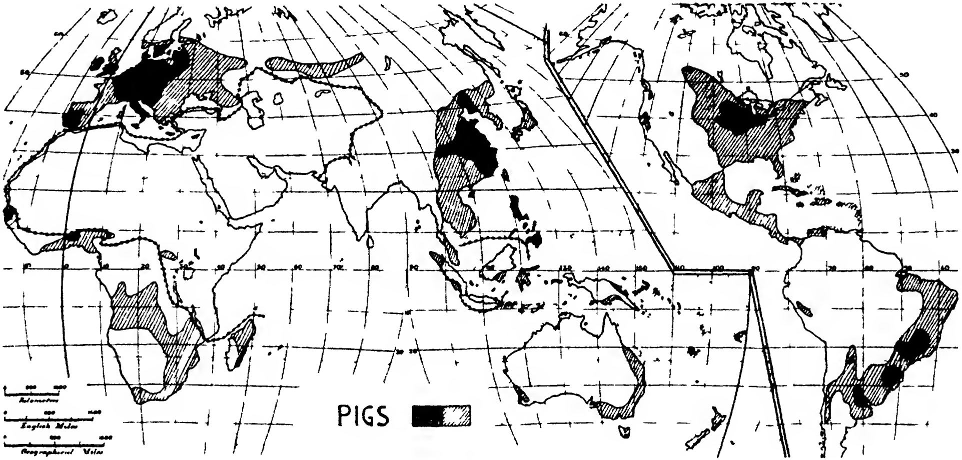


Fig. 26.—MEAT. One cube represents 1,000,000 metr. tons. Compare with meat consumption, fig. 47.

As a food, meat is extremely valuable for its protein and fat contents. In several instances cannibalism was found to occur among peoples who had insufficient or no access to other sources of meat, and had to rely solely on starchy foods—although this may have been due to mere coincidence. From the protective point of view the liver is a store of all the important vitamins of the greatest value, especially vitamin A; it is remarkable that epidemics of colds and influenza among peoples of Western civilisation have become more serious since the increase of urbanisation, which often makes it more difficult to obtain milk, and not fashionable to eat liver. Lean meat is rich in vitamin B_1, which is largely lost through modern cooking methods.



Map 36.—CATTLE. Compare with maps 34 and 18. The distribution of the various species is here shown in detail. European cattle is raised over the areas where no other type is mentioned. Dairying areas are shown black; important cattle areas are cross-shaded; lesser areas are simply ruled.
The gayal, closely related to the bangteng. is raised in north-eastern India between the Yak and Brahman cattle areas; its wild counterpart is the gaur.



Map 37.—PIGS. Compare with the distribution of human population. Major areas are shown black. The limit of Islam is shown by the black dotted line—pork is forbidden to Moslems.

where in India Brahman cattle[3] are kept for their work, and for the little milk they give; selective breeding is practically unknown. Most cattle of the African savanna and southern Asia belong to the Brahman species. Other Asiatic cattle species[4] generally are chiefly used as burden or draught animals, and yield very little milk, if any at all.

European cattle[5] have been differentiated into milk, or meat-milk-draught. The main beef areas of the World are the grasslands of North and South America, and Russia; but it may be said that wherever European man went, beef cattle many breeds specialised in meat, milk, meat-and- were introduced, unless climatic or biological reasons made this impossible. The climatic limit is set by pasture needs; where it is very dry, pastures are insufficient. Temperature matters little; there are cattle in Iceland and in New Guinea alike. Biological factors are very important; tsetse flies[6] make cattle-raising impossible on most African lowlands. Hot regions breed dangerous parasites, such as the cattle tick and the buffalo fly[7].

The best beef breeds are Hereford, Shorthorn, and Aberdeen-Angus, the last two being also dairy breeds. Central Europe draws its beef supplies from Simmenthal cattle, bred for draught and milk as well. Podolian cattle found in

3 *Bos indicus*, also called zebu.

4 The Brahman cattle is replaced to the north by the gayal (*Bos frontalis*) which prefers hilly country. On the lofty highlands of Tibet lives the yak (*Bos grunniens*). In the forests of north-eastern India lives the wild gaur (*Bos gaurus*). To the south-east, from Burma to Sumatra, lives the banteng (*Bos sondaicus*); this species is normally wild, but its hybrids with other species have been domesticated. On the coastal lowlands of south-eastern Asia lives the buffalo (*Bos bubalus*).

5 *Bos taurus*.

6 *Glossina morsitans* and other species.

7 *Boophilus australis* (cattle tick) and *Lyperosia exigua* (buffalo fly)

Eastern Europe are being gradually replaced by or crossed with better breeds.

Many valuable by-products are obtained in modern meatworks: tallow, fertiliser, stock and poultry food, trotter oil, glue, rennet (used in the making of cheese), glands (used in the preparation of medicinal extracts). Horns, hooves, bones and hair are also collected and used for several purposes.

The only animal raised almost exclusively for its meat is the pig[8]. Its great advantage over other animals is that it does not require grazing space, since it can feed on almost any vegetable or animal substance. To countries as densely populated as China which could never afford to set apart land for pasture purposes, or to grow large quantities of special fodders, pigs offer the ideal solution of the meat supply problem because much garbage can be used to fatten them, and they require relatively little green stuff.

The greatest pig-raising centre is in China; the maize districts of North America come second, with a much higher standard of breeding and production; the oat-potato plains of Central and Eastern Europe follow closely. Great developments may be expected in the maize districts of South America. The large numbers of pigs raised in dairying districts are fed on skimmed milk, which is a by-product of dairying.

Pigs may be classed as either porkers, yielding meat for ready consumption, or baconers, yielding meat to be preserved. Although any breed may yield either type of meat, baconers generally prefer cooler climate and richer food.

8 *Sus scrofa.*

Herdsmen who could not raise any of the preceding animals because of climatic or other reasons, had to turn to other species for their meat supplies. The Lapps possess large herds of reindeer[9], which yield many products besides meat; reindeer are raised in the Asiatic tundra, and have now been introduced into North America to support the Eskimos. It may not be long before the whole tundra belt round the Northern Hemisphere will support large reindeer herds. The yak of Tibet (map 36), and the llama[10] (*lyama*) of the Andes (map 45) are mainly kept as pack animals, but their meat is sometimes used, although goats and sheep are the main meat source in these lands.

A source of meat which is generally overlooked, but is rather important especially in many southeastern Asiatic countries, is poultry. Several species are kept, fowls[11] almost everywhere, ducks[12] and geese[13] where there is plenty of water. Turkeys[14], which have been introduced from Mexico, have now spread to most American and European countries, Australia and New Zealand. Guinea fowls[15] are less frequently kept. Pigeons[16] are also raised for their meat.

Densely populated countries supplement their meat supply by keeping rabbits[17] and guinea

9 *Cervus tarandus* or *Rangifer tarandus*. The American variety, known as caribou (*caribu*), has not been tamed.
10 *Lama glama*.
11 *Gallus gallus*; the wild fowl of India, *Gallus bankiva*, is its wild counterpart.
12 *Anas boschas*. The muscovy duck, *Chairina moschata*, of South American origin, is also kept.
13 *Anser anser*.
14 *Meleagris gallopavo*.
15 *Numida meleagris*.
16 *Columba livia*.
17 *Oryctolagus cuniculus*.

pigs[18]. These rodents—the guinea pig is not a pig and comes not from Guinea but from Peru—multiply so rapidly that they are the cheapest source of meat. Only lack of human population has enabled rabbits to become such a pest in Australia; the same has happened on some islands in Bass Strait, and in Macquarie Island.

Until recently, every community had to provide its own meat, and although there was a great trade in grains, many other vegetable foodstuffs and meat could not be sent over long distances because they would decay in transit. Meat export took therefore the form of live animals, with much inconvenience to the animals themselves, and to their fellow travellers. When live animals were exported "on the hoof," they lost much fat, and reached their market in a quite exhausted condition, unless good feeding grounds and water were available on the way and stages were very easy. Where fattening grounds were available and markets within reach, as in the cattle-maize lands of North America, meat could be obtained and consumed in large quantities. Where there was no market, either no cattle raising was developed beyond local requirements, as in Australia; or only the hides, hooves, horns and tallow were used, and the meat allowed to rot as happened on the grasslands of South America. The boiling down of meat to make concentrates or extracts, or the salting of it, were the only ways of avoiding part of this enormous waste, and were first used in Uruguay and Northern Argentina. Later on when meat-freezing was discovered and it enabled meat to be transported over long dis-

18 *Cavia cutleri.*

tances by land or sea, no barrier any longer existed between producer and consumer. Beef, mutton and lamb-raising developed to their present stage in South America, and Australia. When chilling was applied to meat, consumption markets were enabled to receive it as if it had just been slaughtered, and further developments in the export of meats took place.

Canning ensures meat preservation for any length of time and reduces the bulk of exports; a further step is made by dehydration, which deprives meat of most of its water content[19].

Much meat is still preserved by the very old systems of drying, salting, or smoking it, or any combination of two such systems. This is done with most meat consumed by nomadic people, who must be able to transport it easily; this is also the origin of the bacon and ham industry which is so important at the present day.

19 Pork may lose as much as one-third of its weight in water. A 500-lb. beef carcase may be reduced to 60-70 lbs. of dehydrated meat. It has been estimated that Great Britain alone imported 3,000,000 tons of water every year with foodstuffs that could be dehydrated.

XII. OTHER ANIMAL FOODSTUFFS.

Herdsmen soon learned to milk the females of the animals they kept; a variety of animals is used for this purpose. Lapps and other tundra peoples use reindeer milk; Mongols and Arabs use camel milk (map 45), although most of their milk supply is from goats. Mongols and Turks use mare's milk; the highlanders of Tibet and the Andes milk yak cows and llamas (*lyamas*) respectively, but keep also goats. The most important milk-yielding animal is the cow, replaced by the goat wherever pastures are too poor or the ground too rugged.

Dairying as an organised industry is based only on cow's milk, and developed only where there is enough moisture long enough to ensure a constant supply of rich fodder. These requirements limit dairying under natural conditions to regions receiving a uniform rainfall (map 36). Regions where a periodical drought sets in must be provided with water suitable for irrigation from wells, dams or canals. Good dairying production requires careful breeding, cleanliness and skill.

Milk does not keep very long in warm countries, so it must be consumed soon after it is obtained. This is possible only where there is a rather dense population, served by fast means of transport. Modern devices, such as refrigerating cars and vans, are used only where the great demand makes this necessary; people living in densely-populated poor communities, such as China or India, must keep their own cows to milk, or do without milk—only the industrial areas of the Northern Atlantic shores could afford sch n-

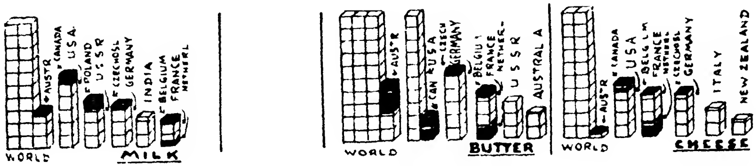


Fig. 27.—DAIRY PRODUCTS. One cube represents 100,000,000 hectolitres of milk or 100,000 metr. tons of butter or cheese.

Dairy products are among the richest sources of vitamin A, which is necessary to keep the mucous membranes in a healthy condition. Thus a high incidence of colds, influenza, or miscarriages among a town-living community may be partly due to the unhealthy condition of people deprived of this vitamin. Dairy products are the only source of vitamin D, necessary to ensure tooth and bone formation. The human body can form this vitamin if it is exposed to sunshine; hence the great importance of dairy products in countries where sunshine is poor during part of the year, and cold temperatures force people to cover most of their skin area. Dried milk and cheese are rich in calcium. All these products are valuable sources of fats, butter being almost entirely constituted by fat.

tific milk transport. The World's dairying districts are therefore distributed on both sides of the Northern Atlantic; the European side continues east into the Eurasian black-earth belt, which is the most promising dairying district of the future. New Zealand has become the most important dairying country of the Southern Hemisphere (map 36).

The main dairying breeds are Jersey and Guernsey, raised in the small Channel Islands of the same name; Frisian, which was first evolved in the Frisian Islands; Shorthorn, bred in England; and brown Alpine, raised in Switzerland. There are very many other breeds of local interest.

Man learnt very early to make use of the milk he could not consume at once, by transforming part of it into butter or cheese. Butter is obtained by bringing together mechanically all the parts of fat which are in suspension in milk. In cheese the same result is achieved chemically, and the casein is also retained. Butter may become rancid after a certain time, unless it is salted—some peoples use it rancid, many salt it, and others use it fresh. Cheese keeps much longer than butter. Butter production is larger than cheese production, but proportionately more cheese than butter is exported. Taste is also an important factor in deciding whether butter or cheese is to be produced. The North American dairying districts produce more butter than cheese; the same is true of the Western European dairying area (Eire, the Netherlands and Denmark) which produces most butter for the industrial areas of Britain. New Zealand follows the same trend.

The Central European area (Germany, Switzerland, part of the Netherlands) produces much more cheese than butter.

Cheese may be either hard or soft. The best known hard varieties are the English Cheddar, Cheshire and Stilton, the Dutch Edam, the French Gruyère, the Swiss Emmenthaler, the Italian Parmigiano. The best known soft varieties are the French Camembert and the Italian Gorgonzola. There are many other varieties, and most European regions have one or more local types of cheese.

Milk preservation is a modern discovery; its most important products are condensed milk and powdered milk. Both methods presuppose a certain industrial organisation which only a few countries have achieved as yet.

Two important by-products of dairying are casein and chocolate. Casein is obtained from skim milk, and is used for many purposes, in foods and for the chemical production of important plastic materials[1]. It is mainly produced in countries which do not specialise in further treatment of their milk production. Chocolate has been already mentioned when dealing with cacao; chocolate-making is a skilled industry, which has been developed in a few specialised centres, of which the North American and British industrial areas and Switzerland are perhaps the best known. A recent discovery makes it possible to obtain a wool-like fibre from specially treated skimmed milk.

Eggs are obtained mainly from fowls, but also

1 Readers with some knowledge of chemistry are referred to "Plastics," by Yarsley and Couzens (Penguin Books).

from any other species of domestic poultry. Nothing is known of egg production in many Asiatic countries, but it may be assumed that it is not as large as the number of fowls might justify, because of the scanty food the birds are able to obtain. There is no selective breeding which could improve their egg-laying standard and the eggs are exceedingly small. China, Japan, Thailand and other countries have achieved wonderful results in the breeding of fowls and ducks for ornamental purposes, or of fighting cocks, but little has been done for better egg production. In countries of European civilisation, egg production is more or less correlated to the number of people, with the great egg-producing areas situated near the great human clusters.

Eggs keep only for a relatively short time, and modern devices, such as egg drying and pulping, have been invented. Other preserving systems, such as refrigeration or chemical treatment, are used for short distance transport, as from parts of Europe to Britain. Powdered yolk, powdered albumen, and liquid eggs (egg pulp) are exported by countries which have to send them very far, for instance, by China and Australia.

Honey has lost much of its importance since the great development of sugar production. Honey bees can live in almost any climate where man lives, provided there are enough flowers to provide nectar. The black bee[2] lives in cool or cold Regions; the golden Mediterranean bee[3] prefers warm Regions.

2 *Apis mellifica.*
3 *Apis ligustica.*

XIII. ANIMAL FIBRES AND OTHER PRODUCTS.

A certain caterpillar[1] feeding on mulberry leaves spins around its body a cocoon of a sticky silken thread. This thread is very long, tough, elastic, and shiny, and it is easily woven. Silk is still preferred to the more easily produced rayon, when very strong tissues are required; for many articles rayon is now used because of its lower cost.

The present distribution of silk production is determined by the climatic requirement of both the caterpillar and the mulberry tree, and further limited by the need for plentiful and patient labour, because the "beds" on which the caterpillars feed have to be changed every few days, mulberry leaves must be picked from the trees and evenly laid on the "beds", and an even temperature must be kept in the room. Open-air raising of the caterpillar, as is done sometimes in Southern China and Southern Japan, yields silk of poor quality. There is as a rule one generation of caterpillars a year, in spring, but in Japan it has been possible to raise two generations in the year, one in spring and one in autumn.

The main silk-producing country is China, followed by Japan. Minor centres are in other warm or hot Asiatic countries, north-eastern Italy, and the Rhone Valley in France.

Wools and hair are produced in much larger quantities than silk; the main difference is that wools are easily felted, i.e., converted into a mass

[1] *Bombyx mori.* The caterpillars of other moths, *Antherea mylitta* of India, *A. pernyi* of China, *A. yamamai* of Japan, produce a thread which is known as tussore silk.

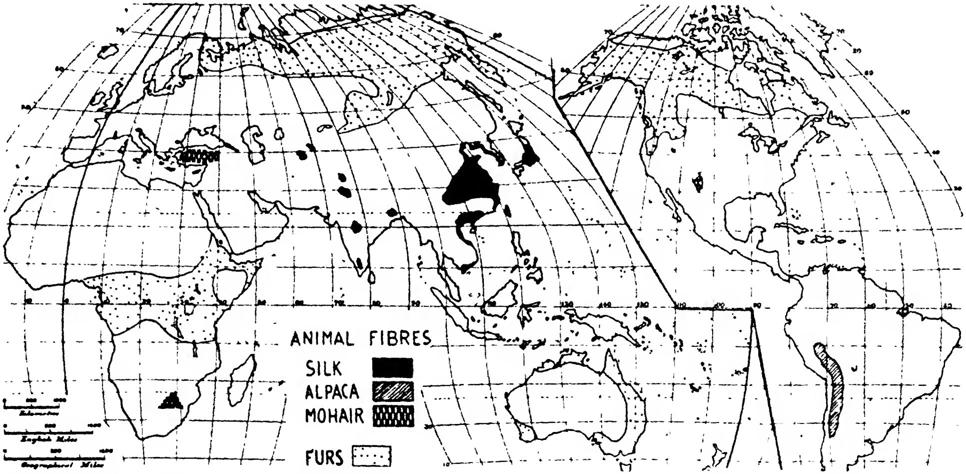
of interlocking fibres whereas hairs do not felt. Wool is the second most important textile material in the World (fig. 21), far more important than cotton in cold or desert climates because of the protection it affords not only against cold but against temperature changes.

The main wool-producing animal is the sheep. Different types of wool have been evolved as a result of selective breeding practised during a very long time. They are classed according to their fineness; length of staple is also important, because too short wool may be difficult to spin, and wool of uneven length renders some operations almost impossible. Semi-dry climates favour production of very fine wool, such as Australian merino; Cool West-coast climates favour production of coarser but longer and shinier wool, such as most British wools. Crossbred wool, with any intermediate degree of fineness, length and shine, is obtained by crossing merino and British breeds; it is very important in most intermediate climatic Regions.

The best known long-woolled British breeds are Lincoln, Leicester and Romney Marsh; the last is best adapted to rainy country, where other breeds are more liable to foot rot[2].

Many countries where no selective breeding is practised have a large production, which is not worth very much. Comparisons are therefore difficult or even impossible. The semi-dry lands of Australia are by far the most important merino-wool producers for both quality and quantity, except in the north, where pastures are too coarse for sheep. The Cool West-coast Regions of the south-east, Tasmania and New Zealand are

2 A disease caused by a small organism, *Fusiformis nodosus*.



Map 38.—ANIMAL FIBRES--FURS. Silk production is practically limited to China and Japan, with a few very small areas elsewhere. By far the greatest variety of furs come from Cold Regions. Africa provides mainly monkey and antelope furs, Australia mainly "possum" furs. The distribution of the Texan-Mexican skunk and that of the South American coypus are not shown. Australia south of the tropic and New Zealand provide most of the World's rabbit fur.

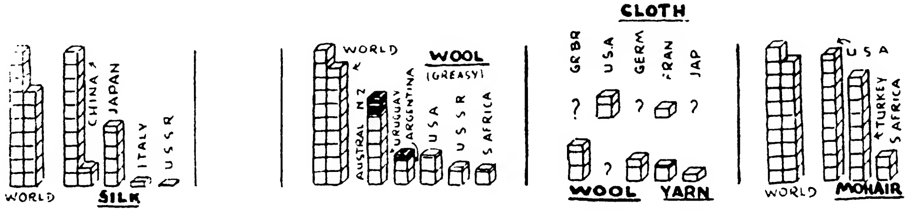


Fig. 28.—ANIMAL FIBRES. One cube represents 10,000 metr. tons of silk, or 100,000 metr. tons of wool or woollen products, or 1,000 metr. tons of mohair. Note Australia's position as a wool producer, and its absence as a producer of woollen goods.

Wool affords a much better insulation against heat or cold than any vegetable fibre. Synthetic wools such as lanital (milk wool) have been improved greatly and may be serious competitors for natural wool. On the other hand, processes have been discovered which make wool unshrinkable, moth-proof, and not irritating to the skin.

also very important; they support mainly cross-bred or British-bred sheep. After Australia, the main wool-producing area is in the southern half of South America. The United States comes next, with a large production which is being improved by scientific breeding. The semi-dry lands of the Soviet Union carry a large flock which has ranked low in value because of several reasons, namely, lack of selective breeding, of hygienic treatment for sheep, of modern shearing appliances, but great progress is now being made (map 35).

Wool as obtained from the sheep is greasy; this grease is not removed before export, because it prevents felting or matting during the transport. The operation of removing the grease is known as scouring, the grease is called lanoline and is used in the making of fine soaps and ointments.

The first stage of wool manufacturing may be carding or combing. Carded or combed fibres are spun to form the yarn, which is then woven. Worsteds are woollen cloths in which the single threads are still visible; woollens have been treated so that only a woolly surface can be seen.

The greatest concentration of wool manufactures is found in England, mainly around Leeds and Bradford; next comes north-eastern France, with very important mills around Lille. Central Europe has many mills, especially in Germany. In the United States, most mills are situated in the North-East (fig. 28).

The Angora goat[3] yields a fibre known as mohair. The goat is now raised in the semi-dry lands of the United States, in Turkey, and in South Africa (map 38 and fig. 28).

[3] A variety of the common goat, *Capra hircus*.

Rabbit hair is required in very great amounts by the felt industry; it is obtained mainly from Australia.

Valuable fibres are obtained from animals living at great altitudes; on the southern slopes of the Himalayas Cashmere goats[3] are raised, which yield a very fine wool. A rather similar wool is that of the vicuña[4] (*vicunya*) which lives wild on the Andes. A variety of vicuña, the alpaca[5], is raised in the same region, and yields alpaca wool.

African and Asiatic nomads weave the wool or the hair of most of the animals they raise (goats, horses, yaks, camels) according to their needs; camel hair has more than local importance, since it is very strong and is used for several purposes, like cow-hair. Horse hair has a certain value for mattress filling and upholstering. Pig bristles are used for the making of toothbrushes and for other purposes.

The greater part of the World's fur production is constituted of ordinary and cheap furs, such as rabbit and hare, squirrel, muskrat, and cat. Rabbit and hare[6] have spread to very many countries, and rabbits have literally invaded the whole of Australia south of the tropic. Hares prefer cold climates, and so do many species of squirrels[7]. Muskrats[8] are small animals related to beavers, and live in the cold parts of North America (map 34). All these fur-bearing animals are rodents. The almost ubiquitous cat[9] is

4 *Lama vicunia.*
5 Some zoologists classify it as a distinct species, *Lama pacos.*
6 Rabbit = *Oryctolagus cuniculus;* hare = *Lepus sp. v.*
7 Squirrel = *Sciurus vulgaris* in Europe, *S. cinereus* in North America, and many other species.
8 *Fiber zibethicus.*
9 *Felis domestica.*

a flesh-eater; it is seldom known in the fur trade under its own name. The same is actually true of rabbit furs.

There are many animals which bear valuable furs, and are hunted in relatively small numbers. They mostly live in very cold countries; there are a few species living on highlands, or in hot countries. Most such animals are small flesh-eaters such as sables[10] and stoats[11]; the very rare fur seal[12] and sea otter[13] are both fish-eaters living in very small areas on Bering Sea, and are now strictly protected. There are many species of fox bearing valuable furs, from the common fox[14] which has become a pest in Australia to the polar fox[15] living in the tundra. The blue fox is a variety of the polar fox which is slate grey, whereas the typical polar fox is white in winter and grey in summer. The silver fox is a black variety of the North American red fox[16], with white-tipped hair.

Other valuable fur-bearing mammals are rodents, such as the beaver[17] of cold North America and Eurasia, the coypu[18] (traded as "nutria") of warm South America, the chinchilla[19] of the Andes. Some small flesh-eaters bear less valuable furs than those listed above: such as the once widespread otter[20] living mainly on fish, the

10 *Martes zibellina* of northern Asia. *M. canadensis* of North America.
11 *Mustela erminea*, living throughout northern Eurasia. "Ermine" is the name given to the winter-coated animal; white with black-tipped tail.
12 *Callorhinus alascanus*, now living on the Pribilof Islands.
13 *Enhydra lutris*.
14 *Vulpes vulpes*.
15 *Alopex lagopus*.
16 *Vulpes fulvus*.
17 *Castor fiber* is the Eurasian species; *C. canadensis* the American one.
18 *Myocastor coypus*.
19 *Chinchilla lanigera*.
20 *Lutra lutra*. The wild life of the English countryside is beautifully described in "Tarka the Otter," by Williamson (Penguin Books).

skunks[21] of North America, the small mink[22] of the very cold Regions. The most valuable fur-bearing marsupial is the Australian possum, which includes several species[23]. Some small monkeys[24] of African equatorial forests are also hunted for their black long-haired fur (map 38).

Furs might be divided into "hard-wearing," such as bear, beaver, possum, which are used mainly for men's clothing; and "luxury" furs such as most of the others, used only for women's wear or ornament.

Most hides obtained from cattle, horses, sheep, goats, and pigs are processed locally to obtain leather. Game animals, such as kangaroo[25], deer[26], wild boar[27], pecari[28] (a small South American wild boar) yield very fine leather hides. The main operation is tanning, which is carried out with vegetable or mineral substances.

Leather is made flexible by treatment with alum and other substances. Chamois[29] is leather into which some oil has been worked. Morocco leather is generally dyed goat leather, with a pressed pattern. Russia leather has a special smell because it has been tanned with birch bark. Patent leather is plain leather coated with black varnish. Buckram is a specially treated cloth.

21 *Mephitis hudsonica* is the northern species, *Spilogale angustifrons* the southern one, which lives as far south as Mexico.

22 *Lutreola sp. v.*

23 *Trichosurus vulpecula* (common possum); *T. fuliginosus* (Tasmanian possum); *T. caninus* (short-eared possum). It is preferable to use the name opossum to designate the American species only.

24 Chiefly *Colobus sp. v.*

25 *Macropus major* (forester or great grey kangaroo); *M. ocydromus* (western forester or grey kangaroo); *M. fuliginosus* (Kangaroo Island kangaroo); *Megaleia rufa* (red kangaroo). Also several species of wallaroos or rock kangaroos (*Osphranter sp.*).

26 *Cervus sp. v.*: the skin is the "buckskin" of the trade.

27 *Sus scrofa*.

28 *Dicotyles sp. v.*

29 The chamois of the Alps (*Rupicapra tragus*) is still hunted for its skin as well as for its meat.

Parchment and vellum are obtained from sheep and calf skin respectively; they are now replaced by chemically treated paper.

Tallow is produced in large quantities in the great beef areas of the World.

Strings for musical instruments and tennis rackets are often made of catgut, which is the intestine of sheep or other animals suitably prepared.

Feathers have been used as ornaments in almost every human community, but have now lost much of their importance. Ostrich[30] feathers were once in great demand for women's hats, and ostrich farming developed greatly in South Africa, North America, and Australia; now there is practically no demand for feathers, and most farms have been abandoned. Egret feathers have caused the almost total destruction of some species of egret and heron[31] found in hot Regions. Birds of paradise[32] became nearly extinct through ruthless hunting in the Aru Islands and New Guinea.

Down is economically more important than feathers at present, and while eiderdown[33] is seldom used, goose down is the main material used to stuff quilts and pillows in cold Europe.

The most valuable substance obtained from birds is guano, which will be mentioned with mineral fertilisers.

Ivory is mostly obtained from African elephants[34]; Indian elephants[35] have much smaller

30 *Struthio camelus.*
31 *Egretta sp. v.* and *Ardea sp. v.* respectively.
32 *Paradisea sp. v.*
33 *Somateria mollissima* is the common eider duck of Britain; there are other species.
34 *Loxodonta africana.*
35 *Elephas indicus.*

tusks. Hippopotamus[36] teeth are used for their beautiful ivory, though they are relatively small. Plastics and vegetable ivory have extensively replaced animal ivory.

The most important ingredient used in the making of sealing wax is lac, which is obtained from the body of a small insect[37]. This lac insect attacks several kinds of Indian trees and sucks their sap; the bodies of lac insects are scraped off the branches, melted, and dried in a special way to obtain shellac, which is used in the making of gramophone records and for "French" polishing, and also to make plastic materials. Lac insects clinging to twigs are traded as stick lac; when they are washed off and dried they give seed lac, the liquid obtained as a residual being called lac dye. Beeswax is a useful by-product of the bee-keeping industry.

Cochineal is another animal red dye; it is obtained from the body of a small insect[38] which feeds on the sap of a cactus[39] grown mainly in the Canary Islands.

36 *Hippopotamus amphibius*, living in Africa near the rivers of the forest and the savanna.
37 *Coccus lacca.*
38 *Coccus cacti.*
39 *Nopalea coccinillifera.*

XIV. PRODUCTS OF THE SEA.

It is desirable to separate whales and other sea mammals from other sea animals. The most important whale product is "oil," which is actually the fat stored under the skin of the animal. It is used for many purposes, such as in the making of margarine and other edible fats and soap.

Whales live mainly in cold or very cold seas, reaching in the warm season the edge of the permanent ice-shelf. In the Northern Atlantic and Pacific[1] they have been almost destroyed by ruthless hunting, and are now very rare. Around Antarctica[2] they are still numerous, but protective steps have had to be taken, and now there is an international agreement limiting hunting to certain periods of the year and to whales beyond a certain size. Owing to the relative rarity of whales, other smaller species[3] akin to whales and even dolphins and porpoises[4] are sometimes used for their fat. Most whale oil is now obtained in Antarctic waters.

1 All true whales form two great groups right whales, with no dorsal fin, and well developed "whalebone" in the mouth, and rorquals with dorsal fin, and poorly developed "whalebone." *Balaena glacialis* (Atlantic right whale) lives in the Northern Atlantic, from the Arctic to the Azores and Portugal; *B. mysticetus* (Greenland right whale) lives near the Arctic. Both species are now rare. In the Northern Pacific live *B. japonica* (Pacific right whale) and *Rachianectes glaucus* (Pacific grey whale). Whaling in the Northern Atlantic is now mainly based on *Hyperoodon rostratus* (the small bottlenose), *Balaenoptera physalus* (finnus or fin whale), *B. borealis* (sei), which is also a rorqual and *Delphinapterus leucas* (white whale).

2 Whaling around Antarctica is mainly concerned with *Balaenoptera musculus* (the blue rorqual), which migrates seasonally northwards past the Australian, African and American coasts. There is also a right whale in the Southern Ocean, *Balaena australis* (Antarctic black whale), but it is much less frequent; killer whales (*Orcinus sp. v.*) are also occasionally caught. It may be said that most whale oil is obtained from the blue rorqual.

3 Bottlenoses (*Hyperoodon rostratus* in the north *H. planifrons* in the south).

4 Dolphins = *Delphinus sp. v.*; porpoises = *Phocaena sp. v.*

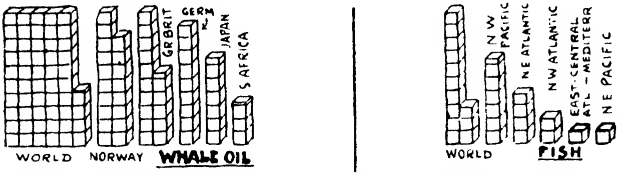


Fig. 29.—WHALE OIL AND FISH. Whale oil is shown by countries of landing; practically all of it comes from Antarctic waters. It would have been of little use to follow the same system when dealing with fish, so a regional classification has been devised. One cube represents 10,000 metr. tons of whale oil or 1,000,000 metr. tons of fish.

After the true whales, the most important sea mammal yielding fat is the sperm whale[5], which lives in warm waters and yields other valuable products.

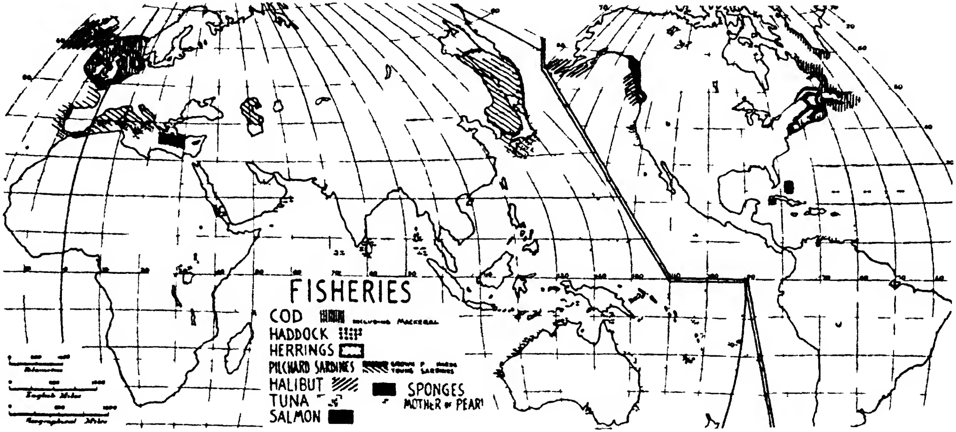
Spermaceti is a wax contained in the head of the sperm whale; it is much used in cosmetics. The fat of the sperm whale is an excellent light lubricant. This animal occasionally produces ambergris, a very valuable greasy substance used in perfumery and cosmetics. Its teeth yield some ivory.

The male narwhal[6] of northern seas, related to the dolphin, carries a long tusk of rather inferior ivory.

Most of the World's fishing is carried out in oceans and seas, and the quantity of freshwater fish is exceedingly small. The best fishing grounds are to be found on the continental shelf near the Cold Regions.

Through lack of exact statistics, little is known of the exact quantity of fish caught in each zone,

5 *Physeter catodon*, also called cachalot.
6 *Monodon monoceros*.



Map 39.—FISHERIES The amount of detail makes it necessary to compare the coasts of North America as shown here, with the same coasts as shown on map 38, in order to distinguish the lines showing the distribution of the various species Other species of salmon are found in the rivers of north-eastern Asia

and how much is caught of each kind. The main economic species of fish probably is the cod[7], caught in the Northern Atlantic, and prepared in several ways, dried, smoked, salted, and also used to produce cod liver oil, one of the most important sources of vitamins A and D. Mackerel[8] is found in the same waters as the cod.

Herrings[9], which when they are small are often called sardines, are caught in the cool and cold waters of the North Atlantic and North Pacific. Tuna (or tunny[10]) are caught in moderately warm waters off California, Japan and in the Mediterranean.

Salmon[11] of various species were once common in rivers flowing into the North Atlantic, but now they are almost extinct. The rivers of British Columbia and Southern Alaska now produce the

7 *Gadus callarias* (syn. *G. morrhua*). Related species are haddock (*Melanogrammus aeglefinus*) which is generally smoked; pollack or coalfish (*Pollachius virens*); hake, ling or codling (*Molva vulgaris*, *Urophycis chuss* and *U. tenuis*) which should not be confused with silver hakes, and are dried and exported in large numbers to Catholic countries to be used as Lent and Friday food; whiting or silver hake (*Merluccius bilinearis* of New England, *M. merluccius* of Western Europe, *M. productus* of California). The swimming bladder of all these fishes yields isinglass.

8 *Scomber scombrus* and other species.

9 *Clupea harengus* is the common herring, perhaps the most important food fish after the cod in the northern Atlantic; *C. sprattus* is the English sprat, whose young are known as whitebait; *C. pilchardus* is the English pilchard when it has attained adult size, whereas its young are known as sardines in more southerly countries. The northern Pacific species are *C. coeruleus* and *C. sagax*, the basis of the tinned fish industry in Japan. A related species, *Alosa sapidissima*, is known as shad in North America, where it is caught when migrating upstream in the Atlantic rivers. The alewife (*Pomolobus pseudoharengus*) is found in north-western North America, in salt as well as in fresh waters. Another related genus, *Engraulis*, is the anchovy of the Mediterranean.

10 *Thunnus thynnus*; in the Pacific it is known as bonito and albacore, although these form now distinct species.

11 *Salmo salar* is the Atlantic salmon, closely related to the trout (*S. trutta*). The Pacific species are pink or humpback (*Onchorynchus gorbuscha*) which is the chief species as to quantity; red, sockeye or blueback (*O. nerka*) which is the chief species as to value; chum (*O. keta*), king, chinook or spring (*O. tschawytscha*) which is the most highly priced; coho, silver or medium red (*O. kisutch*); steelhead (*Salmo gairdneri*) which is much less abundant.

greatest part of the salmon catch of the World; much salmon is also caught in North-Eastern Asia.

It is impossible to mention all other important fish species[12], because they are very numerous, and bear different names in different countries, or sometimes the same name is applied to different species.

The most important fishing grounds stretch from North-Eastern North America, along the coasts of Newfoundland and Labrador, south of Greenland, to Iceland, Scotland and the Norwegian coast, to the whole North Sea. In recent years, Pacific fisheries from Japan to Sakhalin have become even more important, followed by those of the Alaskan coast.

Lobsters, crayfish, crabs and other crustaceans[13] are caught in fair quantities in some waters, and a proportion of the catch is canned. The greatest quantities of canned crayfish come from North-East North America and from South Africa; Japan produces large quantities of canned crab.

Oysters[14] are often bred in shallow waters on special "beds" or wooden supports. They require

12 The United States have developed fisheries of menhaden (*Brevoortia sp. v.*) in the warm waters off their south-eastern coast. The halibut (*Hippoglossus vulgaris*) is caught in large quantities in the Northern Atlantic; there are other species in the Pacific. There are many species which are confused under the name of "mullet"; about 40 species belong to the red mullet group (*Mullus*) and over 70 to the grey mullet group (*Mugil*) to which belongs the chief Australian economic fish, the sea mullet (*Mugil dobula*, sometimes called river mullet). Limit of space permits bare mention of eels (*Anguilla*), plaice (*Pleuronectes*), turbots (*Rhombus*), soles (*Solea*), and among freshwater fishes sturgeon (*Acipenser*), white fish (*Coregonus*), trout (*Salmo trutta* in Europe, *Cristivomer* in North America).

13 Lobsters = *Nephrops*, *Homarus*; crayfish or crawfish = *Palinurus*, *Themis*; crabs = *Cancer*, *Neptunus*, etc.; prawns = *Palaemon*, shrimps = *Crangon*.

14 *Ostrea edulis*; mussels (*Mytilus edulis*) are also raised. Several other species are used as human food, but are not bred by man.

rather warm waters. Large quantities of oyster shells and other shells are used to make shell grit.

Warm seas such as parts of the Indian Ocean and the Pacific, from the Red Sea to New Guinea (map 39) yield certain species of molluscs[15] which sometimes produce pearls, and have their shell lined with mother-of-pearl. The Japanese have found out how to breed pearl oysters and cause them to produce pearls; this is an arduous task, since it takes several years for a pearl to reach a sufficient size, and only a very few pearls are perfectly shaped. Culture pearls, as these pearls from bred oysters are called, have produced a fall in the price of pearls generally, and now mother-of-pearl is more important than pearls. Mother-of-pearl suitable for button-making is also obtained from trochus (*trokus*) shells which are obtained north of Australia, together with trepang or bêche de mer[17] (*be-sh d'mer*), an animal which is used, when dried, as food by the Chinese.

Warm seas such as parts of the Mediterranean and of the Atlantic near the Bahamas (map 39) yield sponges[18]. Red, pink or white corals[19] are obtained from parts of the Mediterranean.

15 *Meleagrina sp. v.;* the species raised by the Japanese for pearl production is *Ostrea martensi.*

16 *Trochus sp. v.*

17 Various species of *Holothuria* and *Stychopus.* In temperate waters are some species of sea urchins (*Echinus*) which may be eaten.

18 The Mediterranean species is *Euspongia officinalis;* other valuable species are found elsewhere.

19 *Corallium rubrum* is the red coral of the Mediterranean: other species are found. *C. secundum* being the main species in the Pacific (Japanese coral fisheries). Very fine descriptions of coral and other forms of life in warm seas are to be found in "Blue Angels and Whales," by Gibbings, beautifully illustrated by the author (Penguin Books).

XV. IRON AND STEEL.

The extraction of a metal from its ore is a very long process. A country may possess valuable ore deposits, and yet be unable to extract the metals which they contain, because it lacks the knowledge or the power resources. In such cases ores may be exported for treatment elsewhere. Other countries thus become great metal producers only through working imported ores.

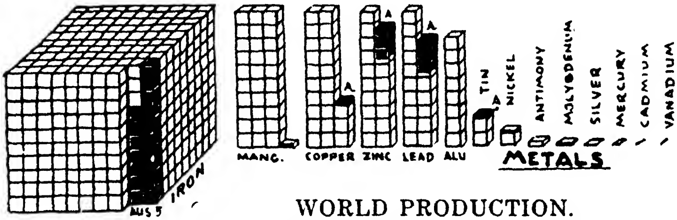


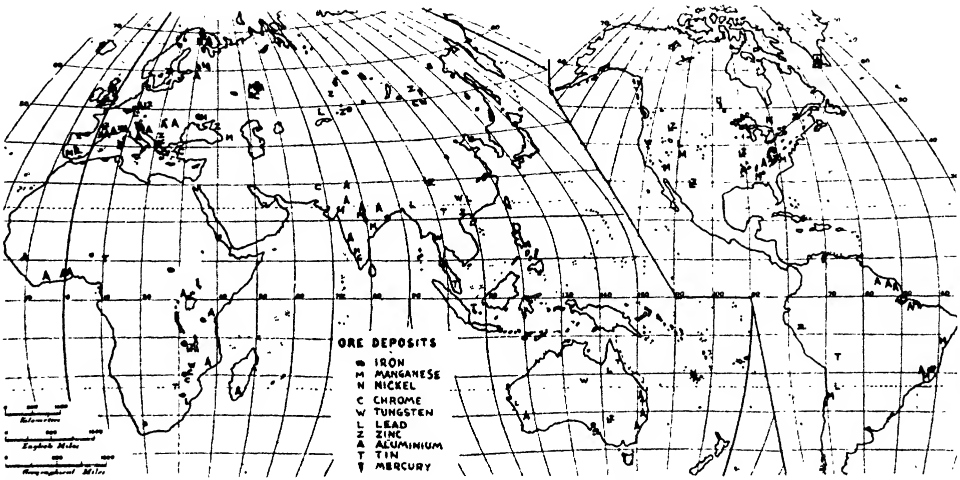
Fig. 30.—METALS. Australian production (A) shown black. One cube represents 100,000 metr. tons.

Iron[1] is the most important metal in a civilisation of European type (fig. 30).

Iron ores[2] are very widely distributed over the Earth. The greatest ore production is from four areas: to the north, west and south of Lake Superior in North America, Lorraine, the area inside the Dnieper bend, Northern Scandinavia. Less important iron-producing areas are northern

1 *Fe*, from Latin *ferrum* = iron.

2 *Haematite* is an iron sesquioxide (Fe_2O_3) containing about 70 per cent. iron. *Magnetite* (Fe_3O_4) with a theoretical content of 72.4 per cent. iron is the most important iron ore; sulphur and phosphorus are undesirable impurities when occurring in magnetite or any other iron ore. Other ores are *limonite* ($2Fe_2O_3.3H_2O$) which is also abundant in some countries; *siderite* ($FeCO_3$) which is much less valuable (48 per cent. of iron) and less frequent; and *iron pyrites* ($Fe\,S_2$) which yields sulphur. Read Fearnsides and Bulman, "Geology in the Service of Man," and Alexander and Street, "Metals in the Service of Man" (Penguin Books).



Map 40.—ORE DEPOSITS. The most important deposits are shown. Note how aluminium and iron ores occur in many localities where other ores are scarce. The aluminium ore found only in Greenland is cryolite, used in the processing of bauxite. Reference to the diagrams should be made in order to appreciate the relative position of each producing country.

England, the Urals, central India, northern Algeria, Eyre Peninsula in South Australia, and southern China.

Two recently discovered deposits of iron ore which are already very important are situated in the Kuzbas (Central Siberia) and in Nigeria.

From ore to steel.

Iron ore . Coal (coke) . Limestone .	Basic slag Pig iron .	Wrought iron Steel (may be alloyed with)	Manganese Nickel Chromium Tungsten Vanadium Molybdenum Cobalt

Iron and steel production is more often influenced by the location of coal with which iron ores are to be smelted, than by any other factors; thus the mines near Lake Superior send their ores to the great smelting centres south of the Lakes, such as Pittsburg, Cleveland or Buffalo. Much iron from Lorraine is sent to the coalfields of Belgium and the Ruhr. The iron centres of the Urals receive coal from farther east. Australia has developed a double-way traffic between the iron-ore deposits of Eyre Peninsula and the coalfield of Newcastle and Port Kembla, so that three cast-iron producing centres are now active, the one near the ore deposits, the others on the coalfields.

The Vale of York, Furness, the Kuzbas and Alabama are some of the very few areas where iron ore and coal are found almost together.

Cast (or pig) iron is the product of blast furnaces, from which basic slag is obtained as a byproduct. Cast iron is rather brittle, not elastic, and must therefore be further treated in order to become industrially valuable.

Some cast-iron is converted into wrought iron, which is tougher; the great bulk is converted into steel. Steel contains less carbon than cast-iron, and this is why it is not as brittle, and most varieties of steel are elastic, although this is due to other factors as well.

The quantity of steel produced often does not correspond to the quantity of pig iron produced in the same areas, because highly industrialised countries are able to recover and melt large quantities of scrap iron, usually mixed with pig iron, thus supplementing their sources of steel.

Steel is extremely important in modern industry, and there is hardly a machine in which there are no steel parts.

Ordinary steel is not suitable for every purpose in modern industry and research goes on continuously so that new alloys (mixtures) of steel with other metals are being made.

Steel is much hardened by alloying it with manganese[3]. The greatest manganese deposits are found near the iron ore bodies of the Dnieper, thus giving that area a very favourable combination of resources. Something similar, on a smaller scale, happens in central India (map 40). The more manganese steel is handled or wrought, the harder it becomes.

Nickel[4] may be added to steel in order to make

3 *Mn.* It is usually combined with iron to form ferromanganese. The chief ores are *pyrolusite* (MnO_2) and *manganite* ($Mn_2O_3.H_2O$) which yield about 62 per cent. manganese. *Rhodochrosite* ($MnCO_3$) yields only 48 per cent. manganese.

4 *Ni.* found in small quantities in nickel sulphide mixed with copper and iron sulphides (pyrites). Monel metal is two-thirds nickel and one-third copper, smelted together from the same ore. E.P N.S. is electro-plated nickel-silver, an alloy of copper, nickel and zinc. Invar is iron with 36 per cent. nickel. Platinite is iron with 46 per cent. nickel and the same thermal expansion as glass (and platinum). Electrical resistance wire is a nickel-chromium alloy.

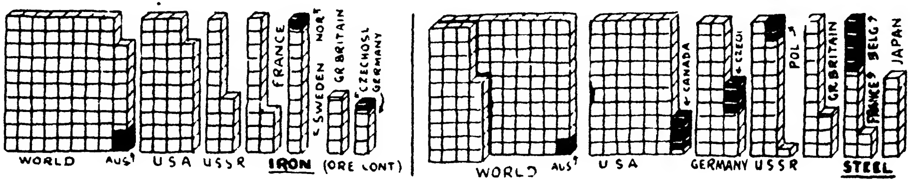


Fig. 31.—IRON AND STEEL. Most countries supplement their pig-iron output by melting large quantities of scrap iron and steel. One cube represents 1,000,000 metr. tons.

Statistics of metal production are usually published in two sets, the one showing the metal content of the ore obtained from the mines, the other showing the metal output of the smelting works. In the case of iron production, this second set of statistics would show the output of pig iron, which is intermediate between the metal content of the ore (left part of the figure above) and the output of steel (right part).

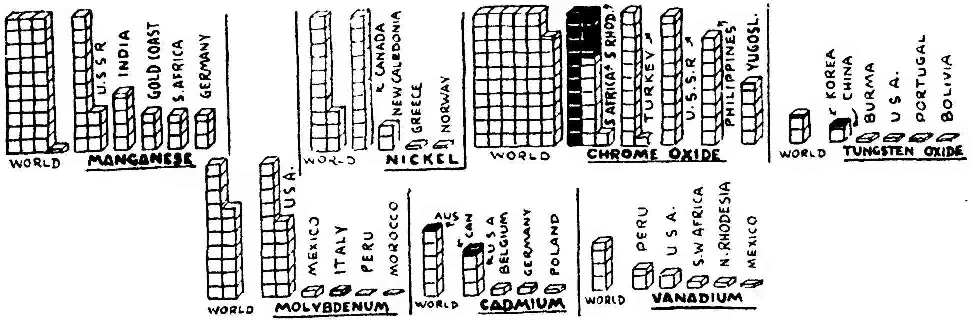


Fig. 32.—STEEL ALLOY METALS. One cube represents 100,000 metr. tons of manganese, 10,000 metr. tons of nickel, chrome oxide or tungsten oxide, or 1,000 metr. tons of molybdenum, cadmium or vanadium.

it tougher and almost stainless. Many countries use nickel coins. The only important deposit known at present is at Sudbury in Ontario. A much smaller quantity is obtained from New Caledonia (fig. 32).

Chromium[5] is used to make stainless and heat-resistant steels, and chromite is used to line furnaces. One of the most widely used steel alloys contains 18 per cent. chromium and 8 per cent. nickel. South Africa and Southern Rhodesia, Turkey and the Soviet Union are the chief producers of chromium (fig. 32).

Tungsten[6] comes mainly from China and Burma. It makes steel harder and heat resistant; pure tungsten is used to make electric globe filaments. Tungsten carbide is used in the making of the most resistant tools, which work under such conditions of speed and heat that no other metal could endure.

Molybdenum[7] strengthens steel, and may replace tungsten in many cases; it is the only steel-alloy metal which the United States produces in large quantities (fig. 32).

Vanadium[8] is alloyed with steel to remove non-metallic impurities.

5 *Cr*, found in *chromite* ($FeOCr_2O_3$) in which chromium oxide represents 68 per cent.

6 *W*, from wolfram, a synonym—although now wolfram is the name given to a tungsten compound, also called *huebneite* ($MnWO_4$). The chief ore is *scheelite* ($CaWO_3$); *ferberite* ($FeWO_4$) is less important. Tungsten is not traded in a pure condition, tungsten trioxide (WO_3) being the compound which is obtained from the ores.

7 *Mo*; *molybdenite* (MoS_2) contains 59 per cent. metal, *molybdite* (MoO_3) 39 per cent., *wulfenite* only 26 per cent. molybdenum.

8 *V*, found in *vanadinite* ($3Pb_3V_2O_8.PbCl_2$) with less than 10 per cent. vanadium, and in *carnotite* ($K_2O.2UO_2.V_2O_5.3H_2O$).

XVI. OTHER INDUSTRIAL METALS.

The most important non-ferrous metals.

Copper	Lead	Tin	Gold
Zinc	Aluminium	Antimony	Mercury

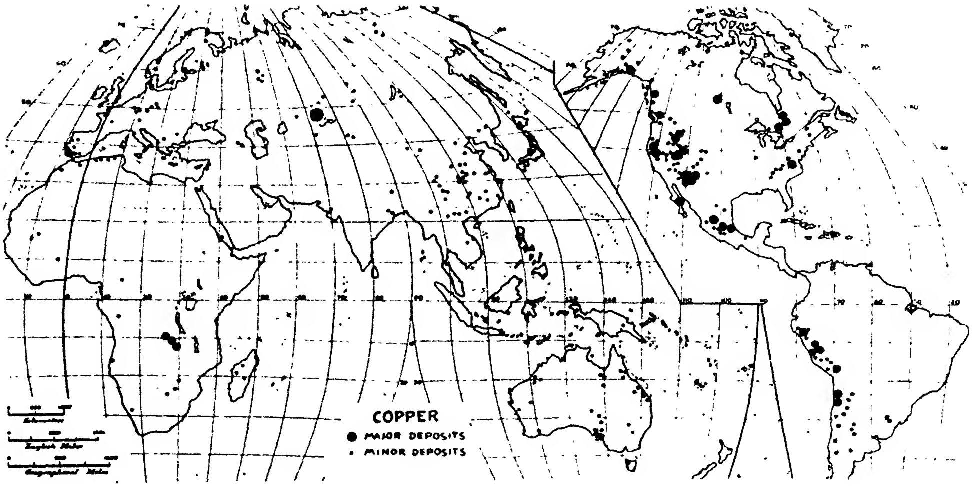
Copper[1] has two extremely important qualities; it can be easily drawn to a very fine wire or rolled to a very thin sheet, and it conducts electricity with less resistance than any other industrial metal. For these two reasons, copper is one of the most important metals, ranking second to iron and manganese (fig. 30).

The largest copper ore deposits are found along the eastern side of the Rocky Mountains from British Columbia to Arizona, and along the western side of the Andes in Chile; another great deposit occurs in the Katanga district (Upper Congo) (map 41). The largest deposit in Asia is found near Lake Balkhash in Kazakhstan. Plenty of electricity is required to refine copper, and this fact decides the location of the great copper refineries.

Copper is often alloyed with zinc to form brass, and with tin to form bronze. Copper or copper alloys are used when non-magnetic metals are required, since iron is magnetic. Beryllium-copper alloys are extremely resistant to corrosion by salt or other agents, and are very hard and elastic.

Zinc and lead, next to copper in importance, are often found together in ore deposits.

1 *Cu*, from Latin *cuprum*. Pure copper is mined in Michigan, but copper ores are a much more important source of this metal. The most abundant ore is *chalcopyrites* ($CuFeS_2$), containing 34 per cent. copper and 30 per cent. iron. Less important ores are *cuprite* (Cu_2O), *atacamite* ($CuCl_2.3Cu[OH]_2$), and *tetrahedrite* (Cu_3SbS_3).



Map 41.—COPPER. Most copper ore occurrences are shown. Compare with maps 14 and 42. Similar maps could be composed for each metallic ore; some good examples are to be found in "Minerals in Industry" by Jones, and "Metals in the Service of Man" by Alexander and Street (Penguin Books).

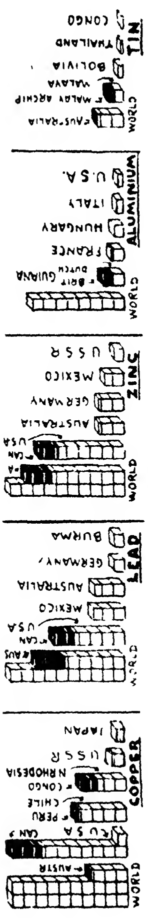


Fig. 33.—NON-FERROUS INDUSTRIAL METALS. One cube represents 100,000 metr. tons of metal contained in the ores mined. The World production of aluminium was about 3,000,000 metr. tons in 1943.

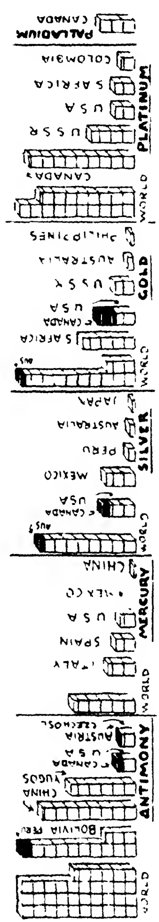


Fig. 34.—OTHER METALS. One cube represents 1,000 metr. tons of antimony, mercury or silver, 100 metr. tons of gold, or 1 metr. ton of platinum or palladium.

Zinc[2] is used to galvanise iron wires and sheets, to make anti-corrosion paints, and to produce brass. Lead[3] compounds are mainly used as anti-rust paint, and in the making of glass and pottery; pure lead is used for tubing and pipes and for storage batteries.

The most important deposits of zinc and lead ores are along the eastern edge of the Rocky Mountains and the Sierra Madre in North America; the most important single deposit is situated at Broken Hill in New South Wales. Mount Isa in Queensland has a fairly large production.

The most important deposits of bauxite, which is the chief aluminium[4] ore, are situated in Southern France, the Danubian Countries, and Guiana (map 40). For the extraction of the metal aluminium from the ore much electricity is needed and consequently metal-producing centres tend to be close to important sources of electricity, such as the Niagara Falls in North America, the Alps and Southern Norway in Europe, Tasmania in Australia. The same is true of copper and zinc, which are now chiefly refined by electricity. Aluminium has a high conductivity of heat and electricity, resists corrosion, is very

2 *Zn.* The most important ore is *Zinc-blende* (ZnS), with about 67 per cent. zinc. *Calamine* ($ZnCO_3$) is frequently found together with zinc blende; although it contains slightly less metal than zinc-blende, it is a valuable ore.

3 *Pb,* from Latin *plumbum.* The chief ore is *galena* (PbS) with over 86 per cent. lead. Carbonated waters change galena into *cerusite* ($PbCO_3$) with over 83 per cent. lead. There are several other lead ores, such as *anglesite* ($PbSO_4$) and *wulfenite* ($PbMoO_4$) which both derive from galena.

4 *Al.* The Americans prefer the spelling *aluminum.* Pure bauxite is $Al_2O_3.2H_2O$, and *cryolite* is Na_3AlF_6. Most aluminium is obtained from bauxite, by a process in which molten cryolite is used as a medium to enable pure aluminium to part from the ore. Synthetic cryolite is now used; natural cryolite occurs in western Greenland only. *Alunite* ($K_2O.3Al_2O_3.4SO_3.6H_2O$) is becoming increasingly valuable as an aluminium ore (map 40).

light and does not form poisonous compounds. It is very much used in the aeroplane industry, and has replaced copper in the manufacture of kitchen ware.

Magnesium[5] is two-thirds as heavy as aluminium, and for this reason its importance as an industrial metal increases daily; it burns with a brilliant flame and is used in fireworks, flares and flashes. Magnesium is obtained from various rocks, and also from brine; the chief localities of magnesium ore production are the eastern Alps in Europe, Nevada, Louisiana and other parts of North America. Underground brine is an important source of the metal in Michigan. Sea water feeds great magnesium works in Texas and northern Germany.

At present the most important application of tin[6] is in the production of tin-plate, a thin sheet of iron being coated with tin and thereby prevented from rusting.

There are only two great tin mining areas; the main one stretches along the mountains of Malaya to the islands of Banka and Billiton; the second area is high on the Andes in Western Bolivia (map 40).

The main use of antimony[7] is in the composition of printing types, for which purpose it is alloyed with lead (which it hardens) and with other metals. The most important mines are in the

5 *Mg*. The metal alloyed with aluminium and/or manganese produces a very hard and light alloy. Duralumin is aluminium with small quantities of magnesium, copper and manganese. The ores are *dolomite* [$CaMg(CO_3)_2$] and *magnesite* ($MgCO_3$).

6 *Sn*, from Latin *stannum*. The only ore is *cassiterite* (SnO_2), with over 78 per cent. tin. Soldering metal is a tin-lead alloy.

7 *Sb*, from Latin *stibium*. The chief ore is *stibnite* or *antimonite* (Sb_2O_3), with over 71 per cent. antimony.

Andes of Bolivia and Peru, in Mexico and in Serbia.

Gold[8] is very resistant to chemical agents and can be drawn out into extremely fine threads, or beaten into thin foils to a much greater degree than any other metal. It is employed to some extent in dentistry, but the quantity used for industrial purposes is very small when compared with the world output; this is due to the fact that, because of its imperishable brightness, gold has been long held a standard for commercial values and used for coinage. As everything was expressed in terms of gold value, it seemed as if gold itself were wealth, and goldmining the most "wealth-producing" occupation. Goldmining actually led to the development of those lands where the most important goldmines are found, such as Transvaal, Alaska and north-western Canada, the Urals (where many more important metals are found), parts of the Western Australian Plateau, and parts of Victoria. Silver[9] is found in small quantities in many countries, often alloyed with gold; Mexico is the largest producer.

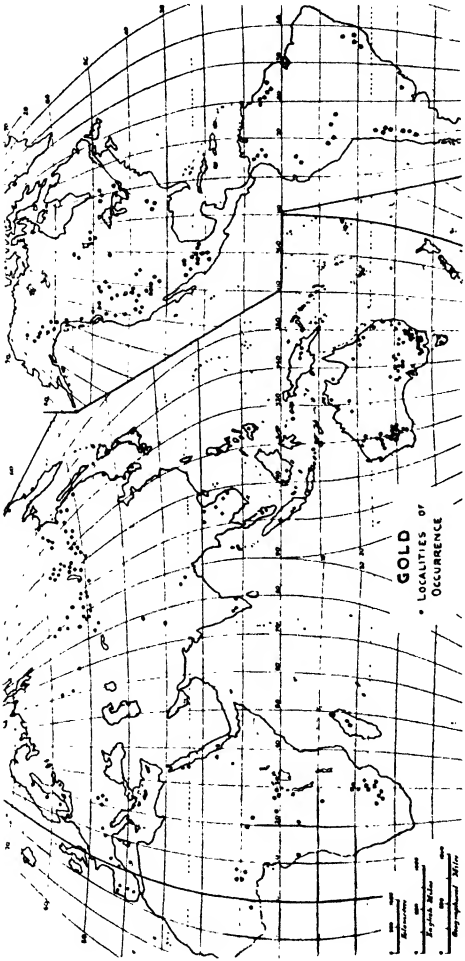
Besides being largely used for coinage and fine cutlery, for which purposes it is generally alloyed with copper and tin, silver is extremely important because some of its photo-sensitive salts are the basis of photography.

Mercury[10] is the only metal which is fluid at ordinary temperatures, and because of this it has

8 *Au*, from Latin *aurum*.

9 *Ag*, from Latin *argentum*. Silver is found pure, but most silver is obtained from such ores as *galena* (with silver), *pyrargyrite* (Ag_3SbS_3) with 60 per cent. silver, *proustite* (Ag_3AsS_3) with 65 per cent. silver, *tetrahedrite* (variety with silver content).

10 *Hg*, from Latin *hydrargyrum*; the ore is *cinnabar* (Hg_2S), with 86 per cent. mercury.



Map 42.—GOLD. Most localities in which gold has been found are shown. Note how alluvial plains and sedimentary rocks seldom yield gold: the Amazon Basin, the Great Artesian Basin and the Murray Basin are typical examples. We know very little about the mineral wealth of Central Asia.

been used in the making of thermometers, barometers, and other instruments. Its property of amalgamating with other metals makes it useful for such purposes, as the separation of gold from the ore and the coating of mirrors. The only two great deposits are in the south-eastern Alps and at Almaden, Spain (map 40).

Radium[11] is found in very small quantities, mainly in northern Canada, Bohemia and the Congo; it is very important in medical treatments for the rays which it emits.

Other metals which are often used in mechanical or chemical industries are arsenic (fig. 39), bismuth, calcium, cadmium (fig. 32), cobalt, beryllium, tantalum, platinum (fig. 34), palladium, osmium, iridium, silicon and titanium.[12]

11 *Ra*. Its main ore is *pitchblende*, in which it is found together with uranium. The scarcity of radium has led to the treatment of other elements, such as sodium and phosphorus, in order to make them radio-active; they can then replace radium in some of its medical uses.

12 Arsenic, *As*, chiefly found in *realgar* (AsS), *orpiment* (As_2S_3) and *mispickel* (FeAsS). This poisonous metal and some of its compounds are used by medicinal and chemical industries.

Bismuth, *Bi*, found pure in central Germany, Bohemia, Bolivia, etc.; it is used in medicine and to make special alloys fusible at mild temperatures.

Calcium, *Ca*, found in many and plentiful rocks. It purifies other metals. Calcium carbide is an artificial product. Calcium fertilisers are very important.

Cadmium, *Cd*, found in Bohemia and Pennsylvania, in zinc ores.

Cobalt, *Co*, occurring in many ores, especially in Ontario. The metal may be alloyed with copper, or used in making pigments for pottery, especially blue smalt. Stellite, used for high-speed cutting tools, contains 60 per cent. cobalt.

Beryllium *Be*, is chiefly alloyed—in small proportions—with copper in order to obtain a strong corrosion-resistant compound.

Beryl—a semi-precious gem—is the chief beryllium ore.

Tantalum, *Ta*, found in tantalite, an iron compound. It is chiefly used in the making of electric lamp filaments and instead of platinum in bone surgery.

Platinum *Pt*, an incorruptible very heavy metal; used in the making of precision instruments, incandescent filaments, etc. The main deposits are in Ontario and in the Urals.

Osmium, *Os*, and iridium, *Ir*, are incorruptible and hard; the former is sometimes used in the making of incandescent filaments, the latter—or the compound osmiridium—in the making of nib tips for fountain pens.

Palladium, *Pd*, chiefly found in Ontario, is used in the making of precision instruments.

Titanium, *Ti*, used in the making of radio valves and in the dye industry. Its ores are *rutile* (TiO_2) and *ilmenite* ($FeTiO_3$).

Silicon, *Si*, used in cast-aluminium alloys.

XVII. NON-METALLIC MINERALS AND ROCKS.

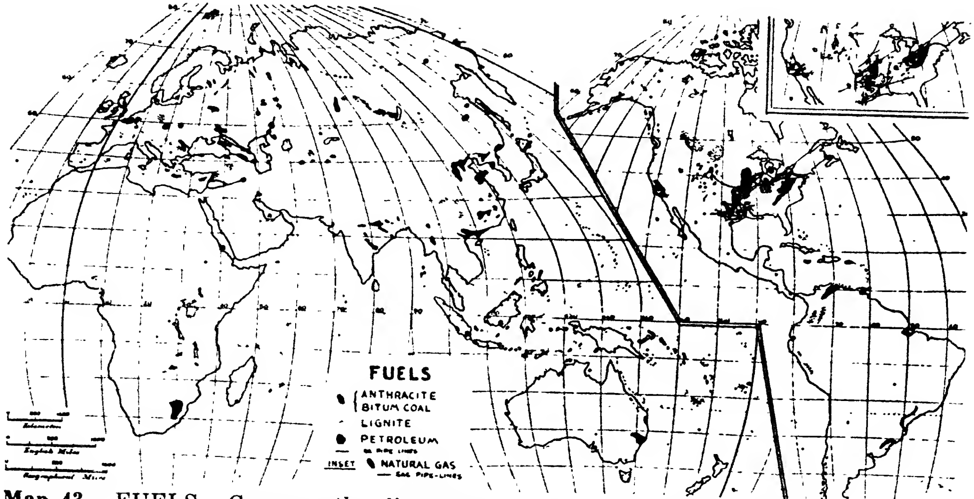
Coal is perhaps the most important non-metallic mineral. It is found in layers in the sedimentary rocks of many countries.

Coal types:

With very much carbon: *anthracite*
With much carbon: *bituminous coal*
With little carbon: *lignite*
With very little carbon: *peat*.

Anthracite contains 90 to 95 per cent. carbon; it is very valuable as a fuel, because it burns with great heat, low flame, and with practically no smoke and little ash. Important deposits are exploited in Pennsylvania and the Donbass (Middle Don Basin); other deposits are found in South Wales, north-eastern China and Tongking.

Bituminous coal is far more important; there are many types, from those which contain so much carbon as to be nearly anthracite, to those which burn with much flame and smoke and leave plenty of ash. Some sorts of coal (with about 86 to 90 per cent. carbon) are used to obtain coke. This is done by "burning" coal without air, thus obtaining a fuel which is nearly as pure as anthracite (carbon 90 per cent.) and by far the most suitable for iron smelting. The by-products of coke production are very many: coal tar is extremely valuable for road-paving and as a raw material for many chemical industries, benzol is often mixed with petrol, gas is the main cooking fuel in modern cities. The distillation of coal tar yields among other products phenol ("carbolic



Map 43.—FUELS. Compare the distribution of coal with that of copper ores shown on map 41. Study the network of United States pipe-lines, which European political boundaries would have made impossible. Correlate the occurrences of coal and iron ore with the development of industries.

Since the map was drawn, a new pipe-line has been built from (Fort) Norman on the Mackenzie River, to Whitehorse in the Yukon Territory and Skagway in Alaska. Other new pipe-lines link Louisiana and North Carolina (788 miles), Florida and Tennessee (462 miles), and Texas and Illinois (550 miles). There are nearly 100,000 miles of pipe-lines in the United States now.

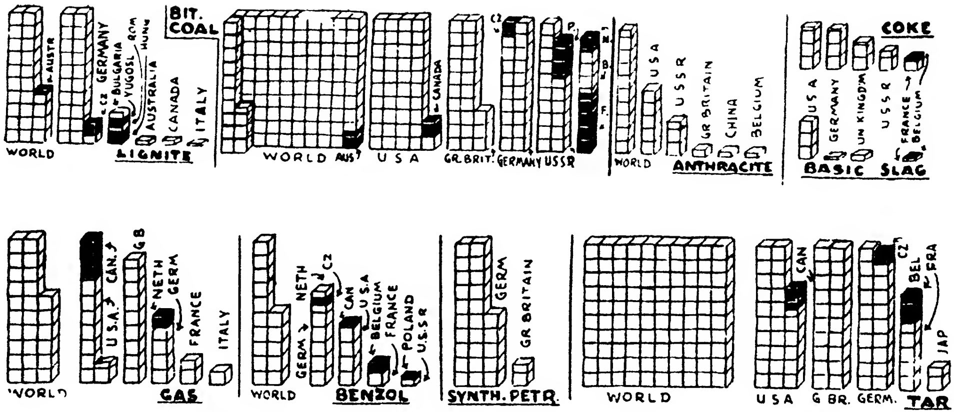


Fig. 35.—COAL. Cz. stands for Czechoslovakia, P. for Poland. One cube represents 10,000,000 metr. tons of lignite, bituminous coal, anthracite, coke or slag, or 100,000 metr. tons of benzol, synthetic petrol, or tar, or 1,000,000,000 cubic metres of coal gas.

acid") and cresol, which are used as disinfectants and for the production of synthetic resins (plastics). Coal and lime are the ingredients from which carbide is made.

The most recent discovery in the utilisation of coal-tar products is the making of nylon, a synthetic substance which has all the useful characteristics of textile fibres, bristles and plastics.

Sub-bituminous coal is poorer than bituminous coal in both carbon and volatile products.

There are many great coal districts in the World; the largest output comes from the Appalachians in North America, northern England and Wales, Belgium and the Ruhr, Silesia, Central Ukraine. Other areas which produce large amounts of coal are eastern India, South Africa, eastern New South Wales.

Coal with 55 to 70 per cent. carbon and in which a woody structure is sometimes visible, is called lignite and is less valuable than ordinary coal. Germany is the greatest producer of lignite.

Peat occurs in bogs and swamps; it contains little or no wooden matter, being mainly formed by stems and leaves. It is always poor in carbon, and it contains very much water, so that it has to be dried before being used. Dry peat contains up to 60 per cent. carbon. Enormous peat deposits are forming under the tundra; in cold or cool countries peat is likely to form wherever there is some precipitation and insufficient drainage. Where better fuels are available they are preferred to peat, but in some northern lands peat has been and is very valuable to man.

Petroleum, popularly called "oil", was known for thousands of years, especially in the Caucasus

and Iran. It became important as a source of power quite recently, after the invention of the internal combustion engine. Like coal, it is found only in stratified rocks, and occurs in North America (Appalachians, Middle West, Gulf of Mexico, Western California). Very important supplies have been found in northern Venezuela. In the Old World the oldest known deposits are still being exploited round the Caucasus, supplemented by newly discovered fields in the southern Urals. Other reservoirs have been discovered in Iraq (*Irakh*), Iran, central Burma, southern Sumatra and southern Borneo (map 43).

Petroleum as a source of power will be discussed later; most products which are obtained from petroleum distillation are used to develop power. Kerosene and petrol vapour are used for lighting: kerosene is also burned in special heating stoves. The heaviest petroleum products, such as paraffin, asphalt and others are used in many industries; the most important are lubricating oils, without which fast-moving machines could not operate (fig. 36).

Asphalt is sometimes found in a natural state; there is an asphalt pool in Trinidad, and crusts of asphalt float on the Dead Sea. Ozokerite (mineral wax) is found near the Caspian Sea.

There are many other valuable minerals.

Salt[1] is the only mineral food which man has knowingly used since very early times. The keen demand for it in lands far away from the sea has already been pointed out. Meat, fish and butter

[1] Common salt is a mixture of several distinct salts. *sodium chloride* (NaCl) being the most important one.

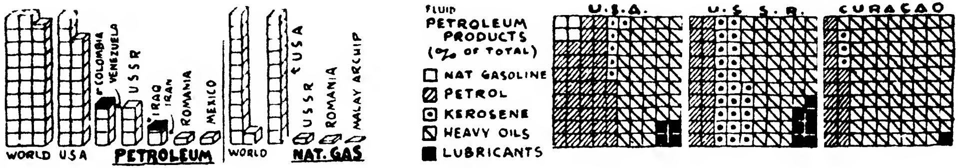


Fig. 36.—PETROLEUM, NATURAL GAS AND PETROLEUM PRODUCTS. Natural gas is used as a fuel in few countries; in other countries it is simply allowed to escape. The diagram to the right shows petroleum products from the least to the most dense; Curacao works petroleum extracted in Venezuela. One cube stands for 100,000,000 metr. tons.

Natural gasoline is also called casing-head gasoline, to distinguish it from straight-run gasoline from distillation, and from cracked gasoline. Kerosene is often called paraffin oil in the United Kingdom; its main characteristic is a high flash point, usually above 100° F, to make it safe for home use. Crude petroleum itself varies greatly in composition, the two great groups being paraffins (light petroleums) and naphthenes (heavy petroleums, with high lubricating-oil and asphalt content). Appalachian petroleum is paraffinic, Indiana petroleum is paraffinic but with sulphur impurities difficult to remove, Gulf petroleum is either paraffinic or naphthenic, and its sulphur impurities are easily removed; Californian petroleum is naphthenic, with much asphalt.

preservation would be sometimes impossible without salt.

The main source of salt is sea water; it is let into flat very shallow pools, which are then cut off from the sea, and dried by evaporation, thus leaving the salts which were dissolved in the sea water in solid form. Dried lakes and saltpans are another source of salt; their salt may be very pure, or mixed with sand or other matters. Finally, rock salt is sometimes found in large underground deposits.

Sulphur[2] is found either in extensive deposits of "native" sulphur, such as occur in Louisiana and Sicily, or in some iron or copper ores (pyrites) as in Spain, Japan, Norway and many other countries. Sulphur is important, for instance, to vulcanise rubber, but much more so when chemically combined to form sulphuric acid, which is the basis of many industrial products, from fertilisers to explosives (figs. 37 and 38).

Fertilisers may be classed according to their main active element as nitrogenous, phosphatic, or potassic.

Rock phosphate[3] is found in several countries, the main centres of production being Florida and Texas, the Kola Peninsula, Tunisia and Morocco, Nauru and Ocean Island. It may be used as a fertiliser without further treatment, or it may be chemically treated with sulphuric acid, and converted into superphosphate of lime. Another phosphatic fertiliser is basic slag.

Nitrate of soda is mined in northern Chile; in

2 S. See Jones, "Minerals in Industry" (Penguin Books).

3 Rock phosphate contains from 40 to 80 per cent. of phosphate of lime, which is the actual fertilising substance. *Apatite* is the chief mineral ($CaCl.Ca_4P_3O_{12}$, or $CaF.Ca_4P_3O_{12}$).

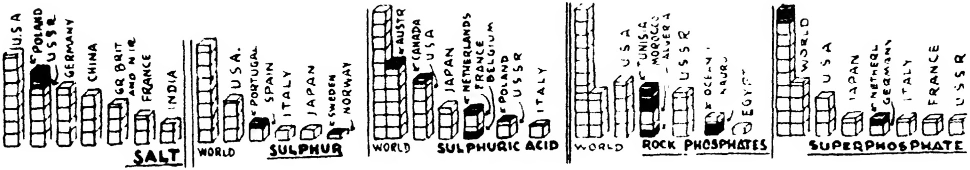


Fig. 37.—NON-METALLIC MINERALS AND SUPERPHOSPHATE. Not all the great sulphur producers produce large quantities of sulphuric acid. Similarly, a great production of superphosphate may be based upon imported rock phosphate. One cube represents 1,000,000 metr. tons.

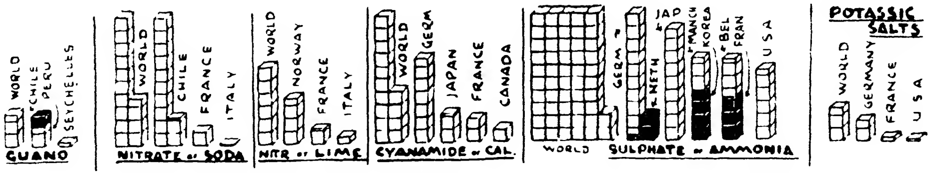


Fig. 38.—FERTILISERS. One cube represents 100,000 metr. tons.

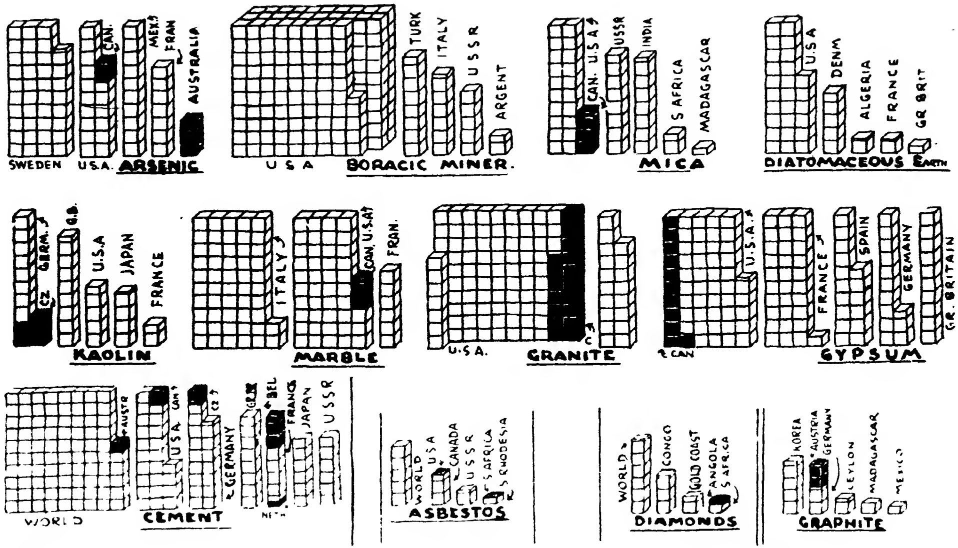


Fig. 39.—OTHER NON-METALLIC MINERALS AND BUILDING MATERIALS. One cube represents 1,000 metr. tons of arsenic, boracic mineral, mica or asbestos, 10,000 metr. tons of diatomaceous earth, kaolin, marble or graphite, 100,000 metr. tons of granite or gypsum, 1,000,000 metr. tons of cement or 1,000,000 metric carats (200 grammes each) of diamonds. N.B. The second producer of granite (after U.S.A.-Canada) is Sweden. Arsenic should be considered as a metal according to some of its chemical properties.

other countries smaller quantities are synthetically produced from nitrogen obtained from the air. Since much electricity is required in the process, highly industrialised countries only were able to establish this industry, for instance, the United States, Germany and Japan.

Guano is a very active fertiliser which is found on rainless islands and coasts where sea birds nest by the million; it is actually an animal product, but it is quarried. Peru and Chile produce most of it.

Potassic[4] salts are found almost exclusively in central Germany.

Building materials are very bulky and consequently very expensive to transport, so generally, in whatever part of the World he may be, man is compelled to build with whatever material he can find near by (map 16).

Limestone is any sedimentary rock constituted by calcium carbonate. Much of it is used in cut blocks, but much more is burnt to provide quicklime, or combined with other ingredients to form cement. Clay is used for the making of pottery, bricks and similar products, and, with limestone, to produce cement. Some sorts of sand are used in glassmaking.

There are many varieties of marble[5] which are mainly used for decorative purposes, largely because they are easy to polish. Other rocks such as granite are seldom polished because of their hardness. Many rocks are suitable for crushing into small fragments for road "metal."

4 *Sylvine, kainite, carnallite, kieserite,* etc.
5 Crystalline and compact varieties of carbonate of calcium.

Gypsum[6], found as a coating in some of the "lakes" of Western Australia, but in solid beds in some other countries, becomes plaster of paris after having been heated to a certain temperature.

Asbestos[7] is the name commonly given to certain fibrous minerals, which can be roughly woven. Their chief value lies in the fact that they are practically fireproof.

Mica[8] is mainly valuable because it is an excellent insulator in electrical works. Borax[9] has a certain value for glassmaking and especially for some chemical industries.

Graphite is pure carbon, and is used as a lubricant and in the making of special crucibles; pencil "leads" are graphite. Diamonds are crystals of pure carbon and being the hardest known substance they are used for such purposes as "arming" drills and for glasscutting. The second hardest substance is corundum[10], which is used in similar ways and also for grinding purposes.

Diamonds, corundum, beryl and other minerals[11] found in fine crystals are called gems or

6 A hydrous sulphate of calcium, $CaSO_4.2H_2O$. Alabaster is a translucent variety.

7 *Chrysotile* (a hydrous silicate of magnesia. green, amber or brown in colour); *crocidolite* (soda-iron silicate, blue); and four minor ones.

8 *Muscovite* ($H_2KAl_3[SiO_4]_3$), *biotite*, *phlogopite*, *lepidolite* (lithium mica, $KLi[Al(OH,F)_2]Al[SiO_3]_3$).

9 When pure, sodium borate with water $Na_2B_4O_7.10H_2O$.

10 Corundum is *alumina* (Al_2O_3); when brightly coloured because of some impurity and in regular crystals it is known as *ruby* (red), *oriental topaz* (yellow or orange), *oriental emerald* (green), *sapphire* (blue), *oriental amethyst* (violet). The best rubies come from Upper Burma and Ceylon; the best sapphires from Ceylon and Thailand. Industrial corundum is known as *emery* (generally mixed with a finely ground iron ore).

11 Beryl, which has been already mentioned as the ore of beryllium, when coloured and in fine crystals is known as *emerald* (green), *aquamarine* (blue-green, or pale green) and is also found yellow or pink. The finest emeralds come from the Urals, Upper Egypt, Colombia; aquamarines come from the Urals, Transbaikalia, Brazil.
The formula of beryl is $Be_3Al_2Si_6O_{18}$.

precious stones; their colour may vary according to their chemical composition.[12]

12 *Chrysoberyl* in the variety known as *alexandrine* is green in daylight and blood-red in artificial light. A yellow-brown variety is known as *cymophane* or *oriental cat's eye*.
Topaz $(AlF\,OH)_2SiO_4$ is typically sherry-yellow, but is also found yellow, brown red, green, or blue. The best typical topaz is found in Brazil, the Urals, and Siberia.
Quartz when pure and colourless is known as *rock crystal;* fine yellow crystals are known as *citrine*, whereas the sherry-yellow ones are called *occidental topaz*, and the light brown ones *cairngorm*. Pink crystals are called *rose quartz*. Violet or purple crystals are known as *amethyst*, by heating they may be changed into yellow *burnt amethyst*. Other quartz varieties are known as *jasper*. A yellowish-brown variety with a characteristic structure is called *occidental cat's eye*.
Fine groups of *crocidolite* asbestos crystals with a typical structure are known as *hawk's eye* when blue and *tiger's eye* (South African 'cat's eye') when golden brown
Tourmaline is considered a gemstone when occurring in fine crystals, it may be pink (*rubellite*), red (*siberite*), green (*Brazilian emerald*), yellow-green (*Brazilian peridot*), yellow (*Ceylon peridot*), or blue (*Brazilian sapphire*).
Olivine when pale green is used as a gem and called *chrysolite*, when dark green it is called *peridot*.
Cordierite may be used as a gem when in fine blue, violet or yellowish crystals.
Spinel in its magnesia varieties $MgAl_2O_4$ is a gemstone when pink, red (*spinel* or *balas ruby*) or blue.
Garnets are complex silicates which may be used as gems. Thus *Uralian emerald* is a green garnet, *almandine* is a deep purple-red garnet and *pyrope* or *Cape ruby* is a blood-red garnet. Yellow or orange garnets are known as *hyacinths* or *cinnamon stones*.
Zircon ZrO_2SiO_2 is also called *hyacinth* or *jacinth* when yellowish red *jargoon* when colourless, yellow, brown, or green. Fine colourless crystals from Ceylon, or artificially discoloured crystals, are known as *matura diamonds*.
Other gems have a micro-crystalline structure
Chalcedony or *calcedony* is called *carnelian* or *cornelian* when blood-red, reddish or brown; if brown in reflected light and deep red in transmitted light it is called *sard*. The dark green variety with bright red dots is called *heliotrope* or *bloodstone*. If layers are clearly visible chalcedony is called *agate*, *onyx* has a black background, *sardonyx* a red or brown one. If a dendritic structure is visible chalcedony is called *mocha stone*
Moonstone is a pale opalescent gem.
Opal is cryptocrystalline hydrated silica, there are many different varieties, such as white, milky, fire, and black opals, the best ones come from New South Wales and South Australia.
Turquoise is also amorphous, it is a blue hydrous aluminium compound, which tends to become greenish with age.
Other substances are semi-precious:
Lapis-lazuli is a deep blue rock, which owes its colour to the mineral *lazurite*.
Jade is a name given to either *nephrite* or *jadeite*, both pale green silicates; true jade is a name reserved for the former mineral only.
Amber, a fossilised resin, has been already mentioned.

XVIII. POWER.

For a very long time, the only source of power known to man was his own strength. Hoe agriculture is possible with human power alone. The natives of most of Africa south of the Sudan, of some Malay Islands, and of New Guinea never knew agricultural implements other than various types of hoe (map 16). On the other side of the Pacific Ocean, hoe agriculture had once reached a high stage of development in Mexico, Central America, and Peru; it is still the only type of agriculture in part of the Amazon Basin and on the higher Andes.

The plough has been adopted long ago by most of the peoples of Europe and Asia; in Africa the nomadic life which has to be led in the savanna has prevented its use being learnt farther south (map 16). In recent times European migration has spread the use of the plough to the Americas, Australia and south-east Africa. The adoption of the plough implies the availability of suitable animal power. In Europe and part of Mediterranean Africa, cattle are trained for the purpose, often with the help of donkeys in the drier countries. Horses replace oxen to pull the plough in many European lands, North America and Australia. In North Africa sometimes camels are used. Over most of India, Africa south of the Sahara, and south-eastern Asia, Brahman cattle are used; on swampy lowlands they are replaced by buffaloes.

Animal power as applied to transport will be studied separately.

Man can use his own power in any way he

wishes but it is not so easy to utilise animal power. Many animals, even when tamed, do not like to have to pull a load or to move backwards, and are often frightened by the very device they have to pull. Animals have to be blindfolded to perform some type of work; this is done by Arabs when they tie donkeys or camels to oil or grain mills or to some device to lift water for irrigation, because turning the heavy millstone or lifting water are tasks which force the animal to walk in a circle for hours.

Man has learned to utilise the great power of wind and water. Wind power is mostly used to propel small boats by means of a sail; only in some countries there remain a few windmills. Water power is most simply harnessed by wheels, fitted with paddles, forming what is called a water wheel. Many European flour mills, sawmills and paper mills are driven by water power.

Wind and water power can be utilised only where windmills or water wheels have been erected, and such wheels are very awkward to move. This is one of the reasons why a mobile source of power stronger than man or animal was badly wanted in Western Europe a few centuries ago, and is still wanted in many lands where no European influence has penetrated. The invention of the steam engine, a powerful and mobile source of power, has led to the great industrial development of England, Belgium, Germany and north-eastern United States, all countries where coal is available to produce heat, and steel is available to make strong boilers. The great industrial clusters on both sides of the North Atlantic owe their development to their deposits of coal and iron.

The invention of the internal combustion engine driven by petrol has affected human progress much more than the invention of the steam engine, because internal combustion engines are very light and can be used to drive vehicles on ordinary roads, whereas heavy steam-driven trains require costly permanent railways. Moreover, flying has been made possible mainly, if not entirely, by the internal combustion engine.

The petroleum industry is now one of the basic industries of modern life[1]. Petroleum is sometimes found in remote places whence it must be transported by pipelines or by tankers to the refineries (map 43). The only petroleum fuel which does not require refining is natural gas. The first product obtained by refining is usually petrol, kerosene comes next, followed by some similar fuels. Next come heavy oils, which are used for diesel engines. The last products of distillation are in solid form, and they have already been mentioned (fig. 36).

Large quantities of petrol are now obtained by further treating some of the heavy petroleum products; this operation is called cracking. Petrol can be obtained from coal by special chemical processes. Petroleum can be obtained from certain shales.

The main geographical effect of the use of petrol engines has been the spread of mechanical civilisation to many countries which were hopelessly cut off from it during the steam period. This intensification of world inter-relationship is one of the great conquests of mankind, and it is

1 Read the heading "Petroleum" and the Chapter "Power" in "Science and World Resources," by Palmer ("Fact," No. 21).

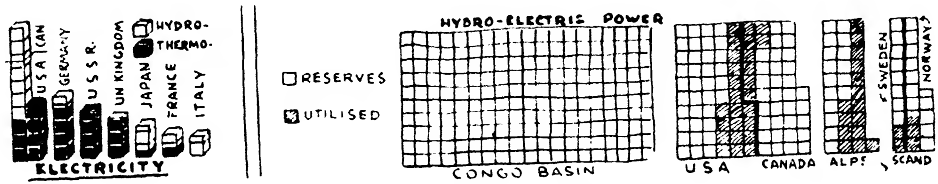


Fig. 40.—ELECTRICITY.—HYDRO-ELECTRIC POWER. The situation of each country should be studied with regard to water-power and coal resources respectively. Find on a map what countries and rivers may be considered as being part of the Alpine area. One cube represents 10,000,000,000 KwH., one square 1,000,000 H.P.

largely due to the internal combustion engine and to petrol.

Power obtained from steam or internal combustion engines or from waterfalls is transformed into electricity by a generator; electricity is conveyed to the place of its utilisation by wires or cables; there it drives a motor which can be used with any sort of machinery. The great advantage of electricity over coal or petrol is that it can be led along wires to great distances from the source of power, thus enabling industries to spring up in the most suitable locations and bringing light to distant places.

Lighting and industrial developments have led to the erection of hydro-electric stations where water power is transformed into electricity and supplied by wires wherever it is needed. Where large quantities of coal are available it is cheaper to have thermo-electric stations, where steam engines supply the power to turn the generators. In the greatest industrialised part of North America, round the Great Lakes, about half the electricity is obtained from steam-driven generators, the other half from water power. This district produces three times as much electricity as the next most important one, southern Germany, where the Alps provide most water power for the purpose. In the Ukraine both coal and water are used to generate electricity; in England practically only coal. Japan, Italy, Switzerland and Scandinavia produce almost exclusively hydro-electricity.

Most hydro-electric stations draw power from natural waterfalls such as the Niagara Falls and the "Fall Line" east of the Appalachians, but man

has been able to create the fall, if necessary, by damming up a river; the most conspicuous examples are Boulder Dam, Grand Coulée and the Dnieper barrage. A complete hydro-electric scheme may imply the erection of a dam, the creation of a lake where water is stored and the flow regulated, all this prior to the erection of the actual power station buildings. It may mean a complete change in the life of one or more mountain valleys and of many districts perhaps hundreds of miles away to which electricity is made available.[2]

2 Thus when the Ural River was held up by a dam near Magnitogorsk, part of the valley was flooded; and when the dam was further raised to increase the capacity of the reservoir, the old abandoned village of Magnitnaya disappeared under the rising waters. It has been held that the decline in the population of some Alpine valleys may be partly due to the fact that hydro-electric reservoirs flood the very best part of these valleys, where permanent pastures, gardens and fields used to be. Hydro-electric plants are very costly to erect, and falling water is less powerful than burning coal; it has been calculated that it takes a one-ton waterfall one mile high to yield the same amount of energy as one burning pound of coal. On the other hand, only 30 per cent. of coal energy can be utilised, the rest being wasted, whereas 75-90 per cent. of water power is utilised in a power station, apart from the fact that the same water can then be used for irrigation.

XIX. TRANSPORT AND COMMUNICATION.

Equatorial forests are far too dense to be traversed by laden animals, therefore human transport is still practised in most of the Congo and Amazon Basins, Borneo and New Guinea. Many men are needed to carry small quantities of goods, and travel is very slow. Burdens are carried on the head. On high mountains some special devices have been evolved to improve human transport, such as the rucksack of the Alps. In equatorial forests paths have to be cut with knives and axes; on high mountains they often have to be carved out of the steep ground.

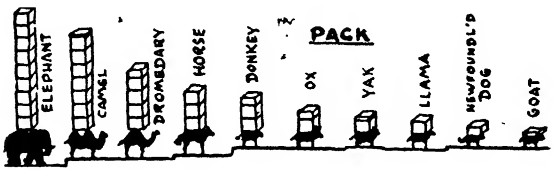
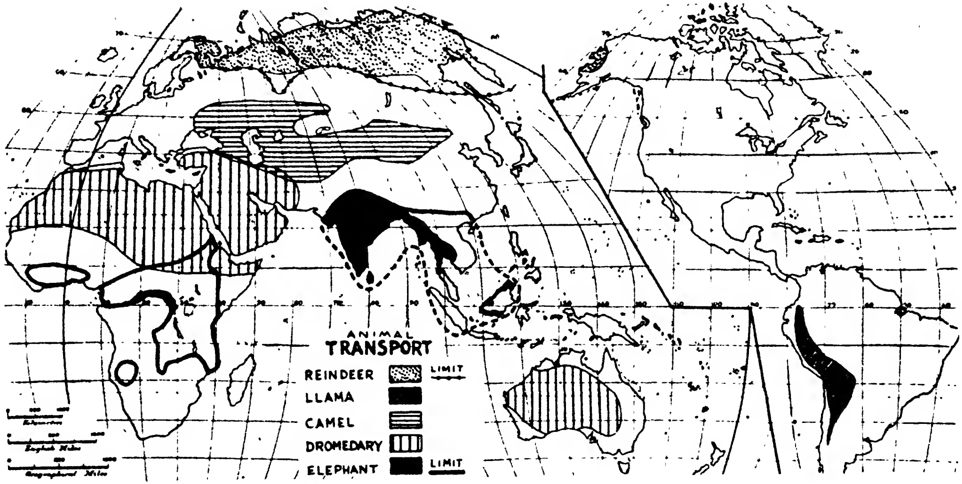


Fig. 41.—PACK ANIMALS. How much an average animal can carry; one cube is 100 lbs. The (two hump) camel carries more than the one-hump camel (dromedary). The donkey is one of the strongest animals relatively to its size. The Newfoundland dog and the goat are seldom used for transport (data from Huntington, Williams and van Valkenburg).

In mountain districts sure-footed animals have been trained to carry loads; in Tibet the yak and small ponies, in the Andes the llama (*lyama*), and in many mountainous lands the mule (cross between a donkey and a mare).

In less rugged and not densely-wooded country, donkeys and horses are used for saddle and pack; donkeys can live on poor pastures and are



Map 44.—ANIMAL TRANSPORT. The areas within which some transport animals are used are shown. The limits of distribution of the elephant and the reindeer include areas where these animals are not used for transport: the African elephant is tamed only at some places in the Congo, whereas the Asiatic elephant is not used for transport in most of Indo-China. Motor transport is replacing the one-hump camel (dromedary) especially in Australia.

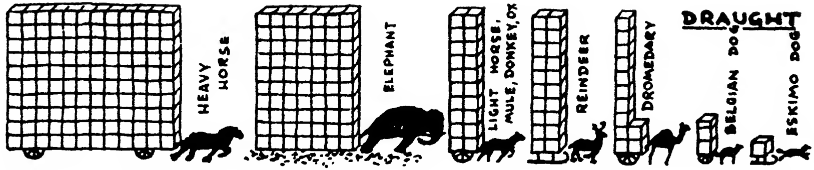


Fig. 42.—DRAUGHT ANIMALS. The elephant drags a load without the help of wheels; skis are fitted to the loads pulled by the reindeer and the eskimo dog. The two-hump camel is seldom used for draught (data from Huntington, Williams and van Valkenburg).

Fig. 43.—RAILWAYS—MOTOR VEHICLES. One bar (from bend to bend) in the graph to the left represents 10,000 km. A cube stands for 10,000,000,000 passenger/kilometers or metric ton/kilometers in the second and third diagram; it represents 1,000,000 motor vehicles in the fourth diagram. One passenger/kilometer is one passenger transported one kilometer; one passenger travelling 100 kilometers means 100 passenger/kilometers, just as 100 passengers travelling one kilometer, or 10 passengers travelling 10 kilometers. Passenger/miles and (British) ton/miles are calculated in the same way.

therefore found in the drier areas. In Desert Regions, where little water is available, camels are the main pack animals; camels and horses alike are used for saddle. Camels can live on very little water, and have very broad feet and long legs, suited to sandy ground. There are two species of camels: the one-hump camel (or dromedary) of the Sahara and Arabia is not as slow as the two-hump animal of Central Asia. Both species are much stronger than horses; the dromedary has been introduced into the Desert Region of Australia.

In Tundra Regions reindeer are used for pack in summer and to pull sledges in winter. In the Siberian and American tundra dogs are used to pull sledges. Both animals are most suited: the very broad hoof of the reindeer hardly sinks into the snow, and the light weight of the dog enables it to run over relatively soft surfaces.

In most other Regions it is possible to use vehicles on wheels. The main draught animals are the horse and the ox. Horse-drawn vehicles are used in most Regions of Europe, North America and Australia; cattle-drawn vehicles are usually seen around the Mediterranean in Europe, and over most of Asia, except the grasslands and the deserts.

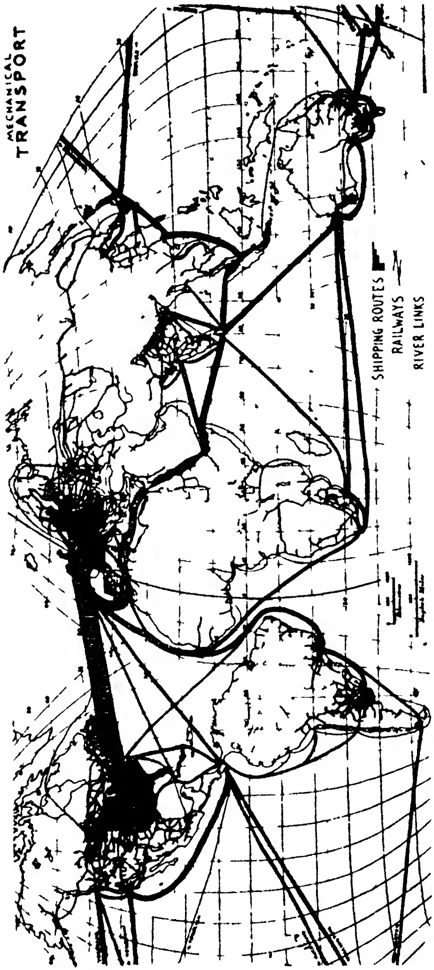
The invention of the steam engine, and the laying of railways on which only special traffic is allowed, have made it possible to carry much heavier loads at a much greater speed than by animal power. Railways have been built in most places where there is a sufficiently firm ground, there is plenty of coal, and there are enough passengers or goods to be carried. In certain cases

railways have been built, which must use imported coal; in exceptional cases even a suitable ground had to be totally built, as near Venice in Italy and Key West in Florida.

The present distribution of railways is shown on map 45; there are two areas in which hardly a place is more than ten miles from a railway, namely, Central and Western Europe, and central-eastern North America. Other European and North American lands show a wider mesh in their railway net: outside these lands it is hardly possible to speak of a net. From Europe a few lines extend towards Asia, to form the Soviet Asiatic system, with the Trans-Siberian reaching the Pacific at Vladivostok. North America has several transcontinental lines, which link Vancouver and San Francisco on the Pacific with New York, Philadelphia and Boston on the Atlantic. Very important are New Orleans where the Mississippi traffic reaches the ocean, and Montreal where ocean traffic goes farthest up the St. Lawrence. From north to south, railways link Southern Canada to Mexico.

There is no railway line between Mexico and South America. South American lines form mainly isolated nets in the grass-covered plains; in the forested areas they link the great navigable streams. In Africa a few railways supplement the navigable sections of the Congo and the Nile. The South African railway system is not as developed as some South American nets.

The Central Asiatic highlands divide the Soviet Asiatic railways from the Indian railways; these have been developed very thoroughly in the Ganges Valley, and the main towns of the penin-



Map 45.—MECHANICAL TRANSPORT. Practically every railway is shown; where two railways are less than 20 miles apart they are shown by one line twice as thick. Rivers are shown only where they link railway lines. Shipping routes are represented by lines of a width proportionate to the intensity of the traffic which uses them; notice how the widest (busiest) route connects the darkest (densest) railway nets.

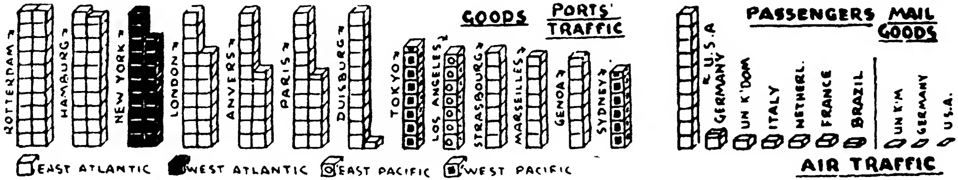


Fig. 44.—PORTS' TRAFFIC—AIR TRAFFIC. New York is the only West Atlantic port among the 13 busiest ports of the World. Paris, Duisburg-Ruhrort and Strasbourg are fluvial ports. Study the hinterlands of Rotterdam, Antwerp (Anvers), Hamburg, Duisburg and Strasbourg. One cube represents 1,000,000 mtr. tons of shipped or discharged goods in the diagram to the left; it represents 100,000 passenger/kilometers or metric ton/kilometers in the diagrams to the right.
The following comparison may be made between air and sea traffic: an 11-knot ship carries up to 7,400 lb. of useful load per H.P., an airplane about 10. Taking speed into consideration, the airplane does in an hour about 4,000 lb./miles of work per H.P. whereas the ship does over 92,000. This is the cause of the apparent lack of proportion between the two sections of the diagram.

sula are also connected by rail. In Eastern Asia, the Soviet system is linked with the Chinese system, which extends as far south as Canton; railways from Indo-China enter China several hundred miles farther south. Japan has an excellent railway net. Turkey, Syria and Palestine are linked with Europe and Africa and not with the rest of Asia.

In Australia there is a railway track which connects Fremantle with Sydney; it is unfortunately divided into several sections of different gauge. It is continued by other railways along the eastern coast to Cairns far to the north. A north-south line from Darwin to Port Augusta has not been completed in the central section. Most Australian and many American railways have been built with a view to further agricultural settlement. Some lines have been built in Desert Regions to serve mining districts.

Narrow-gauge railways are relatively cheap; but on broad-gauge railways heavier loads can be carried and higher speed can be attained than on narrow gauge. This clash between economy and efficiency has resulted in the building of standard gauge (4 ft. 8½ in.) lines in most of Europe and North America, parts of China and India, New South Wales, and from Kalgoorlie to Port Pirie. Broad gauges (over 5 ft.) are found in Ireland, the Soviet Union, Spain, South Australia and Victoria. Narrow gauges (3 ft. 6 in., 1 metre or less) in Western Australia, Queensland, parts of South Australia and elsewhere.

Modern railway developments include the utilisation of diesel, petrol and electric engines. Diesel and petrol engines are mainly used for

light traffic and frequent stops. Electric engines are used mainly in mountainous countries, where coal is not found, but electricity is made available by overhead wires or by a third rail. The Alps and some parts of North America afford the best example of such a development. Suburban electric trains, such as are found in London, Melbourne and other cities, carry very large numbers of people at a higher average speed than steam engines could do.

In several great cities, such as London, New York, Moscow, Paris, where enormous numbers of people have to be conveyed every day to their place of work, underground railways have been constructed. Underground trains are driven by electricity because steam engines would fill the tunnels with smoke and poisonous gas. There are no crossings, and no other vehicles use the tunnels. This renders traffic very smooth, safe and fast.

Tramways are railways for light traffic running alongside or on a road or street. They serve city and suburban traffic; some are extended to serve light country traffic. Power is supplied by electricity, or sometimes by steam or even animals.

Petrol engine and pneumatic tyres have made road traffic important in many countries. Actually, motor cars have now spread to countries where there are no roads; chains on wheels enable them to travel on snow or mud, "caterpillars" travel even on desert sand. Powerful engines are used for regular passenger traffic, and bus lines have been established in many cities, and for suburban traffic. Some lines link cities far apart

in the United States and in England; in Asia, the Damascus-Bagdad service deserves a special mention. Light goods transport on roads offers several advantages; goods can be carried from door to door with a minimum of handling. In some countries, regularly scheduled goods services have been instituted.

Methods of transport by water vary from one country to another. In North America, Sweden and the Soviet Union, rafts are still being made to convey logs to the sawmill. Dug-out canoes are used by most peoples of hot Regions where big logs are available. In many temperate and in cold Regions boats are used which may be propelled by paddles, oars or sails. There are coracles in Wales, bulrush balsas (boats) on Lake Titicaca, circular clay-coated wicker "boats" on the Euphrates, skin hulls on a birch frame in Greenland, birch-bark canoes in Canada. In the Pacific the outrigger is used by several peoples.

On both sides of the North Atlantic the existence of a great sea-faring tradition and plenty of iron and coal have led to the extensive building of steamships. The River Clyde in Scotland is the greatest shipbuilding centre of the World. Great shipyards exist elsewhere in England, the United States, and on a smaller scale in the continent of Europe, Canada and Australia. Many modern ships are driven by diesel or diesel-electric engines, and are called motor vessels.

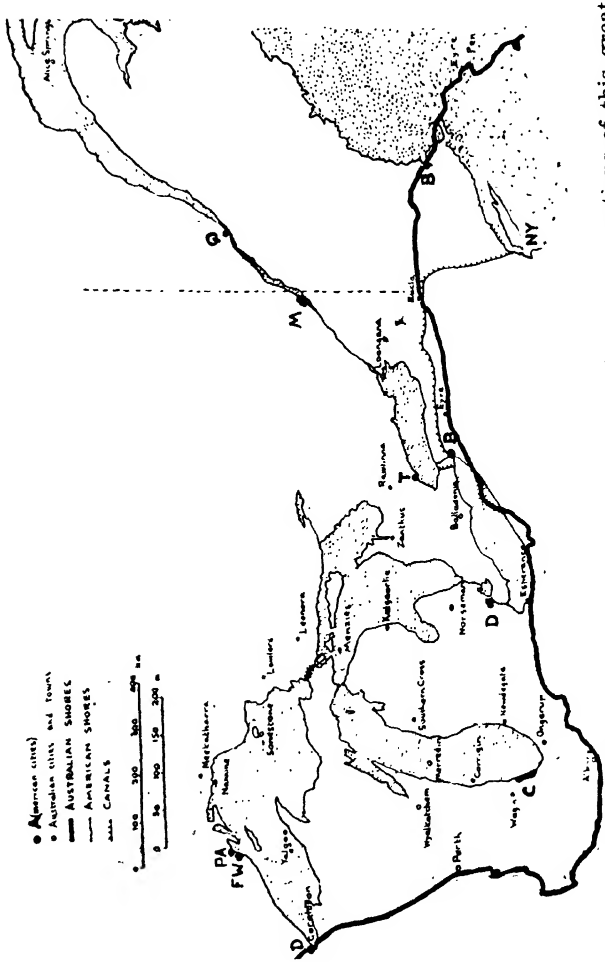
The greatest amount of sea traffic goes on between the industrial centres of north-western Europe and north-eastern North America, which may be termed the North Atlantic iron-coal districts; this is the main sea route of the World

(map 45). The main ports for this route are Rotterdam, Hamburg, London and Anvers (Antwerp) on the European side, and New York on the American side. Other busy routes link Western Europe with the Mediterranean, India, China or Australia; the Pacific with the Atlantic sides of North America; South America with Europe, North America with South America on the Atlantic side; little traffic goes on between Asia and America, Australia and America, Australia and Africa, Australia and Asia[1].

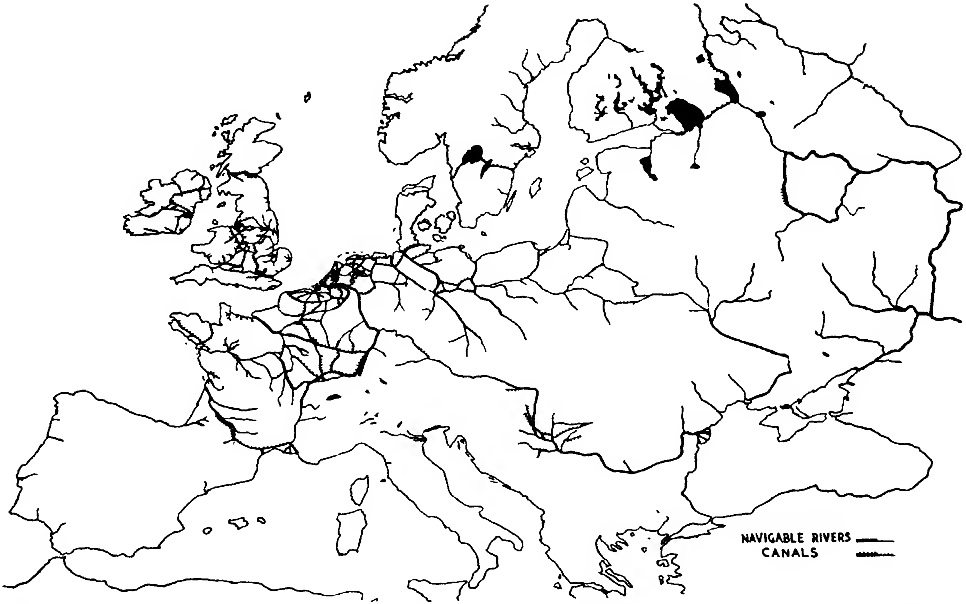
Along certain shipping routes are re-fuelling ports such as Aden, Colombo, Singapore.

Since water transport is cheaper than land transport, navigable rivers are used as much as possible: examples are the St. Lawrence, the Rhine, the Danube, the Volga, the Amazon. It may be desirable to deepen or widen a river in places to make it navigable, or to dig a canal, such as the Soo Canals dug at Sault Sainte Marie (*So Sent Mari*) to avoid the rapids between Lakes Superior and Huron, or the Welland Canal which enables ships to go around the Niagara Falls (map 46). Where ships cannot go farther, barges are used, which require less depth of water; they may be self-propelling, or be pulled by tugs, or hauled by horses, or pushed by paddle steamers as is done on the Mississippi. Many countries have dug a whole net of canals; often canals and rivers form one great system of internal navigation (map 47). In this way Paris on the Seine, Duisburg and Basel on the Rhine, Belgrade and Budapest on the Danube, Moscow and all the centres on the Volga, are reached by

1 See "World Shipping," by Hardy (Penguin Books).



Map 46.—THE GREAT LAKES. In order to show the true proportions of this great waterway, it has been superimposed on a map of Australia on the same scale and projection. Identify the Soo, Welland and Erie-Hudson (or N.Y. State Barge) canals.



Map 47.—EUROPEAN WATERWAYS. Compare with a map showing the height of the land. Identify the great fluvial arteries (Seine, Rhine, Elbe, Danube, Volga) and the great man-made arteries (Baltic-White Sea Canal, Moscow-Volga Canal, Gotha Canal, Kiel Canal, North Sea Canal, Manchester Ship Canal, Corinth Canal). The Volga-Don Canal is not yet completed.

incessant convoys of barges; Paris and Duisburg are among the busiest ports of the World (fig. 44). The best canal nets are found in England, France, Germany, Russia and China.

The Great Lakes of North America are the World's largest internal waterway: wheat and iron ore are carried through the Lakes to the great consuming, smelting and shipping centres. The Lakes are linked to New York by a canal (map 46).

The cutting of the Suez and Panama Canals has shortened some sea routes by thousands of miles. The Suez Canal links the Indian Ocean to the Mediterranean through the Red Sea, and is about 100 miles long[1]. The Panama Canal links the Atlantic and the Pacific through rough country, where ships have to climb 85 feet by means of locks; the Canal is about 50 miles long.

Other canals which affect sea navigation are the Kiel Canal which avoids the Danish Straits; the North Sea Canal which links Rotterdam to the North Sea; the Manchester Ship Canal, which enables ships to reach Manchester instead of unloading at Liverpool; the Corinth Canal; the Baltic-White Sea Canal (map 47).

Air transport is costly when compared with sea or land transport; it is mainly used for the conveyance of letters and valuable small parcels, and for passengers. The development of air lines has taken place where either there are no other means of transport, or important districts need a very fast service. Some parts of the Soviet Union, Colombia, Venezuela, Australia and New Guinea afford good examples of the first type: in New

2 See more details about the Suez Canal in "The Suez Canal," by Schonfield (Penguin Books), and about all canals in "World Shipping" quoted above.

Guinea even mining machinery has been carried by air. Examples of the second type are most of north-western and central Europe, and the United States where close nets of air lines have been established. A third group includes those air lines which may be termed inter-continental: they afford very fast journeys, but the high cost of the service can be met only with government support. Lines of this type link Great Britain with Asia, Australia, South Africa, North America; the Netherlands with Asia and Australia; North America with Asia, Australia, Europe.

Communication of news by means of drums or smoke is practised in many countries; drums are generally used in forests where smoke could not be seen. Mirror flashing and light flashing are used in certain cases even when other methods are available.

The most important means of communication is language. English is the most widespread modern language, being used throughout the British Commonwealth and the United States, and being known by a minority in China, Japan and the Philippines. Mandarin Chinese is used by the educated people throughout China, Manchuria and Indo-China. Urdu-Hindustani, which is used by many people throughout India, is perhaps the third World language, followed by Russian, German, French, Japanese, Spanish (America from Mexico southwards, Brazil excepted, and Spain), Arabic and Italian.[3]

3 This is an estimate of the number of people using the main languages. in millions (in brackets the number of those who partly understand the language without normally using it): English 220 (230). Mandarin Chinese 180 (220). Urdu-Hindustani 90 (210). Russian 140 (60) including Ukrainian 40 (2). German 90 (30) including Yiddish 10 (2). French 55 (70). Japanese 75 (30). Spanish 100 (15). Tamil-Dravidian 65 (15). Arabic 62 (8). Italian 47 (9). Portuguese 44 (10). Javanese 45 (2). Polish 28 (10). Malay 10 (25).

The adoption of symbols to represent ideas, and at a later stage sounds, is one of mankind's greatest achievements. Ideographic writing is used in China and part of the adjacent countries, but has disappeared from other lands. Japan uses ideographic and syllabic writing, many Chinese types having been adopted there with their ideographic meaning, and some simpler types being now used to represent syllabic sounds. Alphabetic writing is much more widely used; the Greek alphabet is the oldest alphabet in present use, but the Latin alphabet is by far the most important one at present. Its Gothic variety is still used in Germany. The Cyrillic alphabet is used by Russians, Ukrainians, Bulgarians and Serbs. The Arabic alphabet is very important, being used with some modifications throughout the Moslem world.[4]

Written messages are now sent by various means; in modern countries mail transport has been taken over by the government, which ensures a regular service by every existing means of transport, and collects a fee called postage for this service. Air-mail is generally subject to higher postage fees.

Most countries have accepted an international agreement concerning mail services, and are members of the Universal Postal Union (Geneva). By this agreement every government effects the transport of foreign mails which have to cross

4 The number of people using the various writing systems may be estimated as follows (millions of persons): Latin 750, Chinese 200, Cyrillic 190, Arabic (including also Iranian, Urdu, Malay, Swahili, etc.) 170, Hindi (devanagari) 80, Gothic 75 (most of these would also use Latin writing), Hebrew 12 (all using also either Latin or Cyrillic writing), Thai-Cambodian 10, Greek 9, Ethiopic 4, Erse 3 (all using also Latin writing).

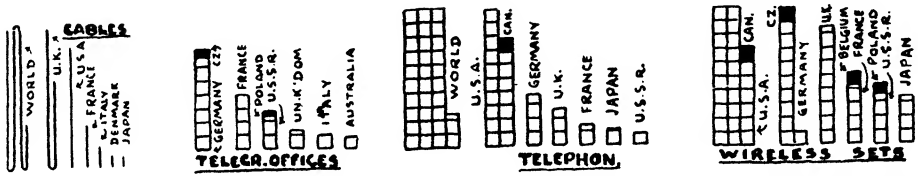


Fig. 45.—COMMUNICATIONS. The ownership of submarine cables is shown; straight lines (bend to bend) represent 10,000 nautical miles. One square represents 10,000 telegraphic offices, or 1,000,000 telephone or wireless-receiving sets. Australia is the first country in the World according to the number of telegrams per head of population.

its respective territory, so that political boundaries are no hindrance to internal postal services.

Electricity has made it possible to transmit words without actually transmitting the paper on which the words are written. The telegraph sends messages by electricity along a copper wire by using either Morse code (dots and dashes) or the usual alphabet. The telephone enables people to speak and hear by wires. In both systems transmission is practically instantaneous. For oversea wire communications, special cables have been laid at the bottom of the sea.

Telegraph services have spread more than telephones because they were invented earlier, and because telegraph service is much faster; special machines have been devised to ensure a very fast transmission of messages, beyond the speed which any man could attain. Telephones are mainly used in cities and large towns, or between such centres; there are many country districts which have a fairly complete telephone net, but most World Regions are still without telephones at all.

Wireless electrical communications are a recent invention; they are now very important because they may replace both telegraph and telephone, and they do not require any installation except the transmitting and receiving stations. Wireless messages are broadcast, and reach any suitable receiving apparatus which is within the range of the transmitting station. The adoption of short-wave transmission has extended the range of broadcasts practically to the whole World; beam transmission enables messages to be transmitted only to receivers situated within a narrow strip of lands along which the beam is directed. Television is now possible.

XX. THE GEOGRAPHY OF INEQUALITY.

The value which man attributes to commodities varies greatly at different times and in different countries; any comparison based on value, and cost or price, may be misleading and often meaningless. A comparison of the quantities of each commodity which are produced in the World during a year is however useful to show their relative importance and to stress the amount of human needs they can satisfy if equally distributed and rightly used (fig. 46).

If every commodity were consumed where it is produced it would be easy to assess the standard of living of each country. But many commodities are exported in varying quantities and any comparison of living standards must take such transfers of goods into account. Production plus imports minus exports can give some idea of the amount of each commodity which is available to the people of each country. There are, however, enormous difficulties in the way of an exact appraisal. Not all commodities are used for the same purpose everywhere. The geography of coffee consumption affords an excellent example: it may be supposed for the sake of argument that two ounces of coffee are made available to persons living in different countries. In Turkey, a good coffee is a thick beverage made with finely ground powder, and large quantities of ground coffee are required: two ounces do not go very far. In Italy, two ounces of coffee would be subject to an import duty of about four times their cost; a strong black coffee would be made, the two ounces would last longer than in Turkey,

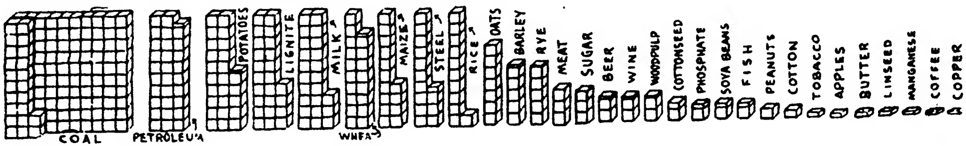


Fig. 46.—WORLD PRODUCTION. How much the World produces of each great commodity in a single year. The oddest associations are noticed: lignite between potatoes and milk, or wine, wood pulp and cotton seed. One cube represents 10,000,000 metr. tons.

but there would be a substantial inroad into the pocket of the Italian consumer. In France, coffee is generally made very weak; the two ounces would make many more cups of coffee than in Italy and in Turkey. In England, coffee is usually drunk with milk: the two ounces could last as long as they do in France, but they actually last much longer—because people generally prefer tea.

It is nevertheless interesting to compare the consumption of various commodities in different countries (fig. 47). Some countries top the list for the consumption of several commodities, and although no sweeping conclusion can be reached, an approximate classification of living standards can be made.

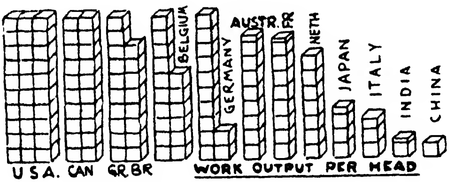
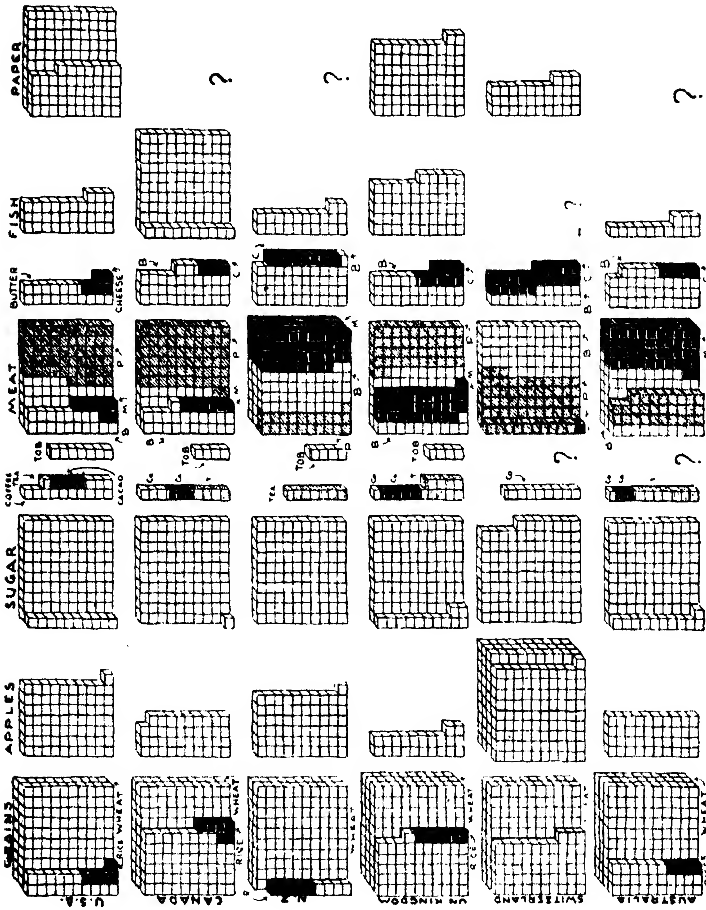


Fig. 48.—WORK OUTPUT PER HEAD. The diagram is based on estimates. Note how mechanisation has raised the output per head in certain countries. Compare, for instance, Japan and China, or France and Italy. "Austr." stands for Australia.

American calculations have obtained an estimated classification of countries according to the total output per head of population. The greatest producing countries, thanks to their machinery and power resources, are the same countries which have reached the highest living standards.



PAPER
FISH
BUTTER
CHEESE
MEAT
TOB
COFFEE
TEA
CACAO
SUGAR
APPLES
GRAINS
RICE
WHEAT
U.S.A.
CANADA
N.Z.
UN KINGDOM
SWITZERLAND
AUSTRALIA

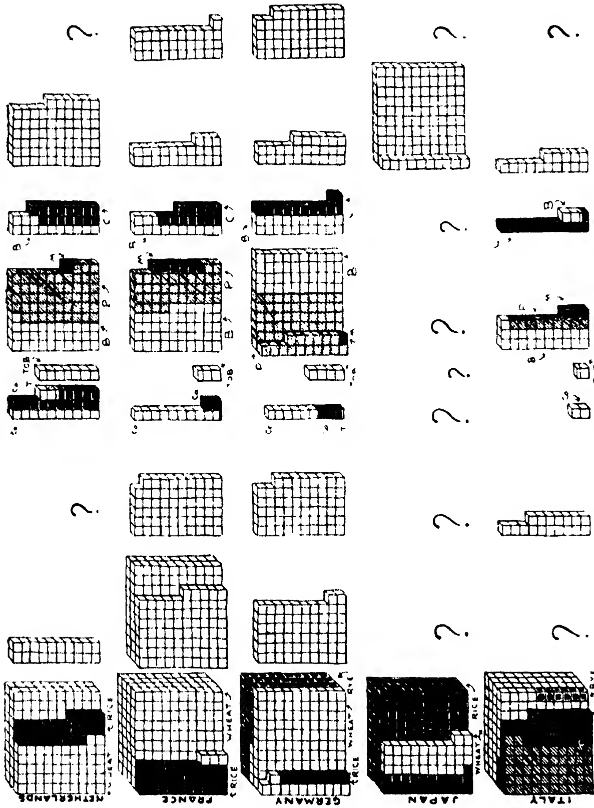


Fig. 47.—CONSUMPTION OF CERTAIN COMMODITIES PER HEAD OF POPULATION. One cube represents 1 lb. per year. Co. stands for coffee, T. for tea, Ca. for cacao, TOB. for tobacco. In the fig. for meat consumption, B. is beef and veal, M. is mutton and lamb, P. is pork, bacon and ham. Butter and cheese are shown by initials except in the top row.

More exact calculations of standards have been obtained[1] by comparing the real income of the average working person in different countries. This comparison takes into account not only the buying power of money in each country, but also —so far as possible—national tastes and habits (see the example of coffee given above) and is therefore the best comparison of living standards so far attempted. Its most serious shortcoming is the fact that it does not consider the number of unemployed persons, who still have to live: while it shows that the average working American enjoys the highest standard of living in the World, it does not show how 7,000,000 unemployed Americans live[2]. This is a type of human inequality that goes beyond the realm of geography but cannot be ignored.

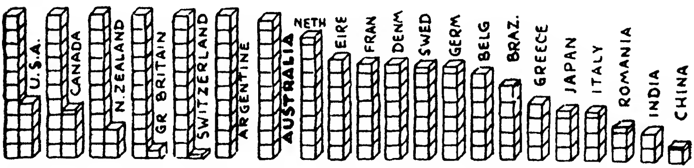


Fig. 49.—REAL INCOME PER HEAD OF POPULATION. The diagram shows the yearly average income per working person: each cube represents the buying power of 100 U.S. dollars (approximately). Based on Clark.

Mechanisation plays a great role in the rise of real income. When real incomes in each country are classified by type of industry (primary,

1 Colin Clark, "The Conditions of Economic Progress."
2 Since "The Conditions of Economic Progress" has been published, the war has affected every country to such an extent, that most figures are out of date. The absorption of unemployed persons in the armed services or in war industries is, however, limited to the duration of the war, and the problems here outlined are likely to occur again as soon as the war is over, unless a thorough planning is enforced in every avenue of production and consumption.

secondary, tertiary) countries and industries where mechanisation is most advanced are by far the best off (fig. 50).

A high standard of living produces an improvement in health through better medical services, hygiene, social amenities and other provisions. Infant mortality is usually measured by the number of deaths among 1,000 children under one year of age. It is perhaps the best index of living standards and hygienic conditions: the lowest infant mortality occurs in New Zealand, Australia, Scandinavia, Great Britain, Switzerland, part of the United States.

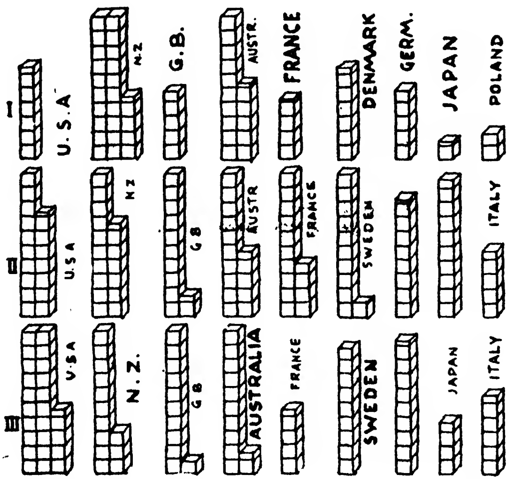
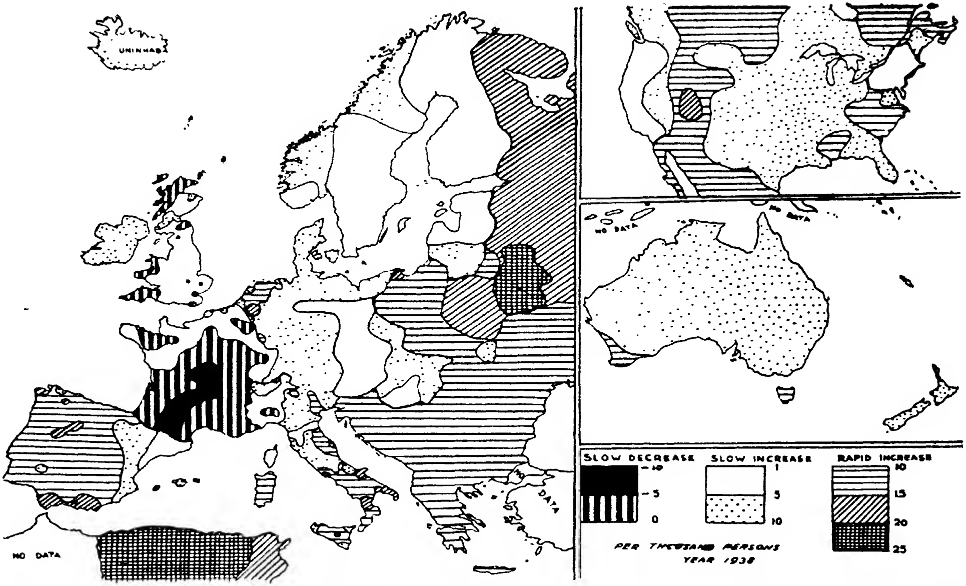


Fig. 50.—REAL INCOME PER HEAD OF POPULATION, BY CLASSES OF INDUSTRIES. I stands for primary industries, II for secondary, III for tertiary. The United States and New Zealand show contrasting tendencies. The implications of this diagram should be studied in detail.



Map 48.—NATURAL INCREASE OF THE POPULATION. Numbers show the difference between births and deaths (per thousand persons) in 1938 (U.S.S.R. excepted). No information concerning Lappland has been mapped. Russian statistics refer to earlier years than 1938, and the increase is likely to have slowed down in later years. The full significance of the situation shown in this map is better grasped by tracing a cross-section of Europe along a line from Moscow to Lisbon, and giving a 5 per cent. increase a height of, say, one-quarter of an inch, a 5 per cent. decrease a depth of one-quarter of an inch, and so on. The French "demographic funnel" would then clearly stand out, and so would the Byelorussian "reservoir."

A low infant mortality rate may show that conditions are very good at that time in any given country, but the future of any country can be seen only through the balance of births and deaths. By subtracting the number of deaths for every 1,000 people from the number of births for every 1,000 people, the natural increase of the population is obtained, which shows how every 1,000 people increase in a year. Although better measurements of population growth have been found,[3] the rate of natural increase is sufficient to show the developments in the near future. The geographical interpretation of statistical data leads to the identification of the great human reservoirs in Eastern Europe, which will shape the course of European history in the years to come.

The geopolitician notices that for the first time in modern history these great manpower reservoirs are located within the Eurasian core which has been aptly called the Heartland[4]; this book has outlined the distribution of World resources, and it can be seen how well endowed the Heartland is. The man of vision may now look into the future history of the World.

3 Kuczynski's net reproduction rate is the best known of such measurements; unfortunately the necessary data are only available by whole States over most of Europe. whereas map 48 has been worked out from statistics by boroughs. *departements*, *province*, *Laender*, etc., as far east as Poland, Czechoslovakia, Hungary and Italy, and by whole States only farther east.

4 Geopolitics on a World plane has been outlined by Mackinder in "Democratic Ideals and Reality" (Penguin Books) in which the words *manpower* and *Heartland* have first been used

APPENDIX.

The Most Important Measures and Their Conversion Coefficients.

LONGITUDE.—Length of 1° of longitude along some typical parallels:

Latitude	Miles	Latitude	Miles
0°	69.16	50°	44.55
10°	68.10	60°	34.67
20°	65.00	70°	23.74
30°	59.96	80°	12.05
40°	53.07	90°	—

The length of 1° of latitude gradually increases from 68.70 miles near the equator to 69.40 miles near the poles.

TIME.—The sidereal year is the period of time it takes the Earth to complete a revolution around the Sun and further to reach the same position in relation to a fixed point in the sky; its angle is 360° and its duration is 365d., 6h., 9m., 9.54sec.

The **solar year** (also called equinoctial, astronomical, natural, tropical year) is the period of time that elapses between two successive spring or autumn equinoxes; its duration is 365d., 5h., 48m., 45.51sec.

The **calendar year** lasts 365 days, but in each year whose number is a multiple of 4 an extra day is added, February 29th. The initial year in each century is however a normal year of 365 days, unless its two significant figures form a multiple of 4, in which case the extra day is added. Thus 1900 had 365 days, 2000 will have 366.

The **day** is divided into 24 hours, which in modern practice are numbered consecutively from midnight (0 h.) to midnight (24 h.).

The **true solar day** is the interval of time between two successive apparent transits of the Sun across a meridian. It varies slightly in length according to the speed of the Earth.

Duration of daylight is quite another matter, and it varies with latitude and time of the year. The actual duration of daylight during the longest day is:

Latitude	Daylight	Latitude	Daylight
0°	12h. 5m.	50°	16h. 18m.
10°	12h. 40m.	60°	18h. 45m.
20°	13h. 18m.	70°	65d. 0h. 0m.
30°	14h. 2m.	80°	130d. 0h. 0m.
40°	14h. 58m.	90°	182d. 0h. 0m.

In the northern hemisphere daylight lasts a little longer at high latitudes.

TEMPERATURE.—1° centigrade (1°C) = 1.8° Fahrenheit.

1° Fahrenheit (1°F) = .55556° Centigrade.

$$\frac{5\ (°F-32)}{9} = °C. \qquad 9\,\frac{°C}{5} + 32 = °F.$$

PRESSURE.—The normal atmospheric weight at 0°C and at sea level balances the weight of a column of mercury 760 mm. or 30 in. high; it is the equivalent of a weight of 14.6974 lb. per sq. in. or 1.03326 kg. per cm.^{2}, and it exerts a pressure of **1,013.25 millibars.**

1,000 millibars (1,000 mb.) = 29.531 in. = 750.1 mm.

WIND.—1 mile per hour = 1½ ft. per sec. = .45 metres per sec.

1 métre per sec. (1 m/sec.) = 2.2 miles p. h.

1 kilometre per hour (1 km/h.) = 5/8th miles p. h.

RAIN.—Inches × 25.4 = mm.; mm. × .03937 = inches.

SNOW.—1 foot of snow = 1 inch of rain (approximately).

LENGTH.—**1 metre** (1 m.) = 100 centimetres (100 cm.) = 1,000 millimetres (100mm.) = 39.37 inches = 3.2808 feet = **1.0936 yards.**

DEPTH.—**1 metre** (1 m.) = **.5468 fathoms.**

HEIGHT.—1 **metre** (1 m.) = **3.2808 feet.**

DISTANCE.—**1 kilometre** (1 km.) = 1,000 metres = 1,093.6 yards = 49.7092 chains = 4.9709 furlongs = **.62138 miles.**

1 **geographical** or **nautical mile** = 1,852 metres = 2,026⅔ yards = **1′ at 45° lat.**

AREA.—**1 square centimetre** (1 cm.^{2}) = **.15498 sq. ins.**

1 square metre (1 m.^{2}) = 10,000 cm.^{2} = **10.76365 sq. ft.** = 1.19596 sq. yards.

1 **hectare** (1 ha.) = 100 ares = 10,000 m.^{2} = **2,4711 acres.**

1 square kilometre (1 km.^{2}) = 100 ha. = 10,000 ares = 1,000,000 m.^{2} = **.3861 sq. miles.**

VOLUME.—1 cubic metre (1 $m.^3$) = 1 stere = 1,000 litres = 35.31338 cubic feet = 1.30794 cubic yards = 423.76056 super feet.

CAPACITY.—1 litre (1 l.) = 1,000 $cm.^3$ = 1.76 imperial pints = .88 imperial quarts = .21997 imperial gallons = 1.057 U.S. quarts = .26417 U.S. gallons.

1 hectolitre (1 hl.) = 100 litres = 21.9975 imperial gallons = 26.4171 U.S. gallons = 2.7497 imperial bushels = 2.8377 U.S. bushels.

WEIGHT.—1 gramme (1 g.) = 15.4323 grains.

1 kilogramme (1 kg.) = 1,000 grammes = 2.20461 lbs. = 35.2734 oz. (Av.) = 32.157 oz. (Troy).

1 quintal (1 q. in German *Doppelzentner*, dz.) = 100 kg. = 220.46 lbs. = 2.2046 centals = 1.968 cwt.

1 metric ton (1 t.) = 10 q. = 1,000 kg. = 2204.6 lbs. = 1.10231 (U.S.) short tons = .98421 (British) long tons.

SHIPPING.—Gross tonnage is the capacity of the whole enclosed space in a vessel; net or registered tonnage is the portion of gross tonnage which is available for cargo or passengers. 1 ton = 100 cubic feet = 2.83 $m.^3$

Displacement tonnage is the weight of water displaced by the fully laden vessel; cargo tonnage is the weight of cargo carried, often estimated at 1 ton = 40 cubic feet of cargo.

TRANSPORT.—1 passenger-kilometre (1 pass. km.) = .62137 passenger-miles.

1 metric ton-kilometre (1 t.-km.) = .612 (British) long ton-mile = .685 (U.S.) short ton-mile.

1 kilogramme-kilometre (1kg.-km.) = 1.37 lb.-mile.

SPECIFIC COMMODITIES. — Cereals: conventional weights of an imperial bushel or a hectolitre:

Cereal.	1 Bushel =	1 Hectolitre =
Wheat	60 lb.	76 kg.
Rice, paddy	45 lb.	55 kg.
Rice, husked	68 lb.	77 kg.
Rye	56 lb.	71 kg.
Barley	48-50 lb.	62 kg.
Oats	32-39 lb.	45 kg.
Maize	56 lb.	72 kg.
Millet	62 lb.	76 kg.
Sorghum	56 lb.	72 kg.

These weights vary according to climatic conditions, standards of seed used, moisture content, etc. The values given above are widely accepted as convenient estimates.

Potatoes: 1 imp. bushel = 60 lb.; 1 hectolitre = 88 kg.

Coffee: 1 bag (Brazil) = 132.28 lb. = 60 kg.

Cotton: 1 bale = 500 lb. (U.S.A.) = 400 lb. (India) = 750 lb. (Egypt) = 400 lb. (West Africa) gross weight.

Jute: 1 bale = 400 lb.

Wool: 1 bale = 1,000 lb. (South America) = 330 lb. (Australia). Weights down to 250 lb. are accepted for merino wool, down to 150 lb. for lamb wool.

Petroleum: 1 barrel = 34.97 imp. gallons = 42 U.S. gallons = 1.5899 hectolitres.

CURRENCY.—Because of the present international situation it is impossible to show the relative value of these currencies here listed by countries.

Country.	Currency.	Country.	Currency.
Abyssinia*	thaler (dollar)	Liberia	dollar
Afghanistan*	rupee	Luxembourg*	franc
Albania*	franc	Malaya	dollar
Argentina*	peso	Manchukuo	yüan (dollar)
Australia	pound	Mexico*	peso (dollar)
Austria*	shilling	Mongolia	tugerig (dollar)
Belgium*	belga	Netherlands*	gulden
Bolivia*	boliviano	Newfoundland	dollar
Brazil*	cruseiro	New Zealand	pound
Bulgaria*	lev	Nicaragua*	córdoba
Canada	dollar	Norway*	krone (crown)
Ceylon	rupee	Palestine*	pound
Chile*	peso	Panama*	balboa
China*	yüan (dollar)	Paraguay*	peso
Colombia*	peso	Peru*	sol, libra
Costarica*	colón	Philippines*	peso
Cuba*	peso	Poland*	zloty
Czechoslovakia*	koruna (crown)	Portugal*	escudo
Denmark*	krone (crown)	Romania*	leu
Ecuador*	sucre	Salvador*	colón
Egypt*	gineh (pound)	Soudan*	gineh (pound)
Eire	pound	South Africa	pound
Finland*	markka (mark)	Spain*	peseta
France*‖	franc	St. Domingo*	dollar
Germany*	reichsmark	Sweden*	krona (crown)
Greece*	drakhme	Switzerland*	franc
Guatemala*	quetzál	Syria*	pound
Haiti*	gourde	Thailand*	baht (tical)
Honduras*	lempira	Transjordan*	pound
Hungary*	pengö	Turkey*	lirasi (pound)
Iceland*	króna (crown)	United Kingdom	pound
India	rupee	Uruguay*	peso
Indo-China	piastre	U.S.A.	dollar
Iran*	rial	U.S.S.R.*	rouble
Iraq*	dinar, rupee	Venezuela*	bolivar
Italy*	lira	Yugoslavia*	dinar
Japan*	yen	Zanzibar	rupee

* Uses the metric system officially.

‖ And Colonies not mentioned in the table.

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NOTES

NOTES

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